

ESTIMATION OF TAX EVASION AND THE EFFECTIVENESS OF TAX COLLECTION FOR THAILAND

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ABSTRACT

Low tax revenue is an acute problem for the Thai Government, one which causes a lack of funds for much needed economic and social development. The cause of the low tax revenue is ineffective tax administration. Thus the purpose of this research was to measure the tax effectiveness in Thailand.

The review presents the popular Tanzi's monetary approach for estimating the level of tax evasion and it has resulted in the hypothesis that tax evasion generally increases alongside the growth of the economy. However, his approach overlooks two aspects which reduce the accuracy of the findings: velocity of money and the legal effect of the tax rate. Thus, in this research, some adaptations were made in order to achieve more accurate estimation. The model was applied to macro-economic data from sources such as Bank of Thailand and Eco Win database covering period 1980 to 2006 and results indicated that tax evasion during this period was probably in the region of 5.5-15%. Figures suggest firstly that as the economy has grown, tax evasion has reduced, but that secondly, the least tax evasion occurred during the economic crisis of 1997. The former finding corresponds to the research by IMD surveys (2005) which showed that highly developed countries have low tax evasion. The latter finding was tested for structural break and the results support the view that there is no change in behavior during the crisis but that the high drop of tax evasion is caused by both the legal and illegal effects of tax rate.

In addition, another method for estimating tax evasion, Tax Compliance Measurement Program (TCMP), was applied in measuring the individual tax auditor performance. This applied method is a good incentive for tax auditors to improve their effectiveness in detecting more tax evasion.

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1 INTRODUCTION

The Thai economy had grown rapidly during 1985 – 1996 until it faced a setback in the 1997 financial crisis. After that, the economy recovered with per capita GDP at \$3,732 in 2007 but it did not grow as fast as earlier. Despite its fair economic performance, the income of 84% of Thai workforces does not reach the first threshold for individual income tax because of poor income redistribution and poverty. To address the problem of poverty, the Thai government needs to develop the country's social and educational institutions. However, it does not have sufficient funds, partly due to low tax revenue and high corruption. For Thailand the share of tax revenue in GDP was 14.4% for the period 1996-2002 (it was 16.2% during 1990-1995) (Table 1). This is less than the share of the tax revenue-GDP ratio of the median developing country, which was 19.2 % in 1996-2002 (and 18.7 during 1990-95). Resolving the low tax revenue problem would contribute to developing education and create a more qualified workforce, thus increasing the percentage of Thais who could contribute to the revenue.

Table 1 Total Government Tax Revenue as Percentage of GDP, 1990-1995 and 1996-2002. (Number of countries and median values of the sampling averages)

	1990 to 1995		1996 to 2001		Direction of change	
	Countries	Median	Countries	Median	Down	up
Developed countries	21	37.8	21	40.1	3	18
Transitional economies	14	34.7	14	31.4	12	2
Developing countries	13	18.7	13	19.2	5	8
Thailand	1	18.6	1	16.8	1	

Note Average taken by median value of simple average.

Source: UNPAN Statistical Database

Source: Fiscal Policy Office, Ministry of Finance (Thailand)

Two main causes of the low tax revenue are defined as the ineffective tax administration, and corruption (Schaffer & Turley, 2000). In addition, this study suggests that poverty is another cause of the low tax revenue. Figure 1 shows that the effective tax rate for Thailand has been more or less increasing with per capita GDP from 1980 onward, with some exceptions, such as the period preceding 1992 and the period of financial crisis (1997). Though per capita GDP picked up the momentum from 1998 onward, the effective tax rate began to rise only after 2000. Moreover, the fall in the effective tax rate was very sharp during the crisis (3 percentage point, or nearly 25% - from 19% to 15%), while the per capita GDP fell 50,000 Baht to 45,000 Baht (10% fall). In 1992 a major tax reform was undertaken and this seemed to have produced some result as the

effective tax rate increased after 1992 after an earlier fall between 1988 and 1992. Table 1 presents the international comparison of the tax revenue-GDP ratio of Thailand and other countries. The Thai ratio is smaller than the median developing countries by about 1 percentage point, and this gap widened for the period 1996-2001. The same ratio for the developed countries is more than twice as large, and for the transition economies it is nearly twice as larger. This research attempts to estimate the effectiveness of tax collection, and identify the reasons for low tax revenues.

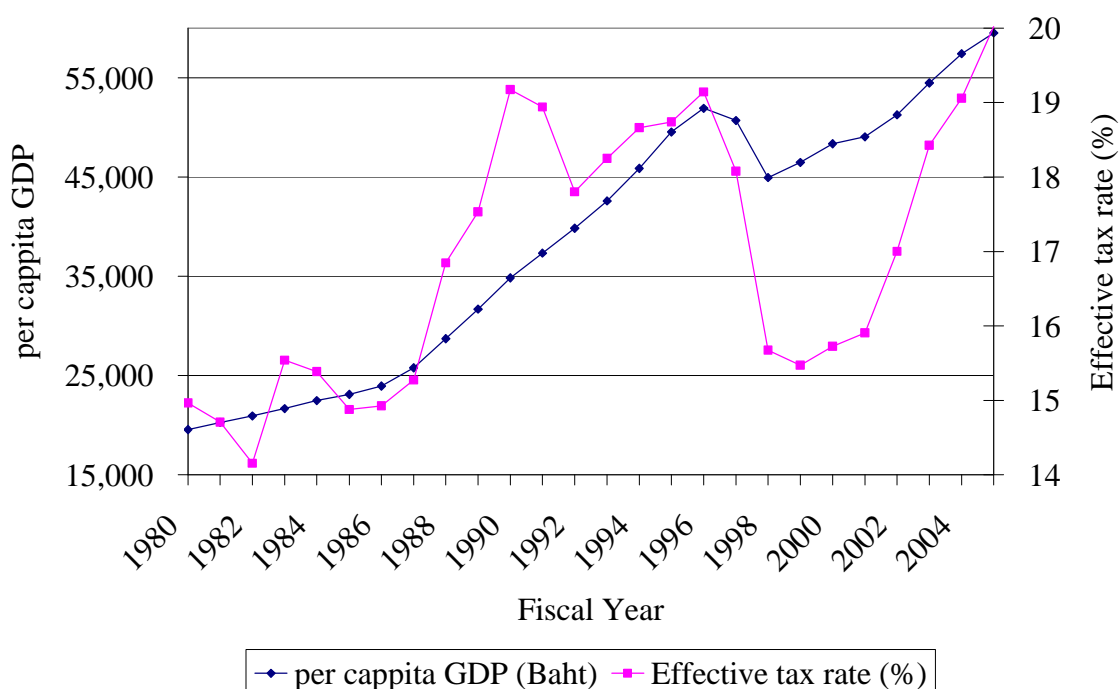


Figure 1 Relationship between income and tax revenue in Thai economy

Source: National account, Office of the National Economic and Social Development Board

1.1 ASSUMPTIONS AND DEFINITIONS

The main assumption for estimating the tax effectiveness, referring to Tanzi's monetary approach, is the positive relationship between a tax rate and tax evasion (Clotfelter, 1983). Increasing tax rates stimulates tax evading activities by using currency to conceal illegal transactions from being detected. This illegal money can be used to estimate the underground economy by comparison with the total money circulating in the economic system. Normally, the velocity of money represents the amount in circulation in the economic system. However, the velocity of illegal money is unknown. Thus the second assumption is that the velocity of illegal money is assumed to be equal to the velocity of

broad money. The reason is that illegal currency is switched from bank transactions which are referred to deposits and the deposits are a majority of broad money. Then it could be said that the ratio of illegal currency to broad money represent the ratio of underground economy or tax evasion rates. For this reason, the definitions of the estimated underground economy and tax evasion in this research are different from the normal definitions. Generally, underground/hidden/shadow economy includes various illegal activities but the underground economy in this research is estimated from the changes in tax rates, so it is specific to only the tax evasion activities. In this paper, the definition of the tax evasion refers to tax evasion using currency to evade tax; it does not include and tax evasion by distortion and corruption. Other definitions are shown as follows.

Effective tax rates are the realized average tax rates (Schaffer, Turley et al., 2000). They can be calculated as collected tax revenues over their tax bases, the detail of calculation can be seen in Mendoza et al (1994)

Currency (C) in Chapter 3 model focuses on only the currency circulation outside the financial institutes.

Narrow money¹ ($M1$) is the money in public circulation comprising banknotes and coins, plus business and household call deposits in the commercial banking system.

Broad money ($M2$) is the money in public circulation comprising banknotes, coins, and call deposits (i.e., narrow money, $M1$) plus business and household time and savings deposits in the commercial banking system, plus promissory notes or deposits in the finance and finance & securities companies.

¹ Definitions of narrow and broad money are from the central bank of Thailand according to Monetary and Financial Statistics Manual 1990

2 THAI TAX SYSTEM AND REVIEW OF THE LITERATURE

This review gives the circumstances of the research question and relevant constraints of the Thai tax system. In addition, the review also gives you the background of tax evasion measurement, especially monetary approaches which were developed from Tanzi's (1983). The tax evasion is the key variable to estimate the tax effectiveness.

2.1 OVERVIEW OF THE THAI SYSTEM

The overview of Thai taxation is obtained from the Tax Policy Bureau (2005) and Sujjapongse (2005). It provides tax structure for both central and local government, tax rate, previous tax reforms, present circumstances, and problems. This information was considered when researching the question and detailed estimation can be found in chapter 3.

2.1.1 THAI TAX STRUCTURE

Tax can be classified by two methods. The first method is to classify tax by resources of income such as profit, labor force income, and goods & services transactions which taxes apply to. In Thailand, there are seven central government taxes and two local administrations' taxes. Only the five predominant tax categories of government revenue are considered in research estimation. They are individual and corporate income taxes, value added taxes, excise taxes and custom duties. The second method classifies tax by types of participants, either as earners or consumers who pay direct and indirect taxes respectively. The direct taxes which apply directly to earners comprise of individual income tax, corporate income tax and local levied taxes. As local levied taxes only make up a minor share of total government revenue, they will not be considered in this research. The tax burdens of indirect taxes are carried more by consumers and earners carry indirectly less as lower sales and income. The indirect taxes collected by the central government are value added taxes, specific business taxes, stamp duties, excise taxes and customs duties. The remaining surcharges on central government tax are collected by local administrations.

Thus, the following sections will firstly present Thai taxation responding by the central government and local administrations, and then the direct and indirect tax will be considered in circumstance of Thai taxation and tax reforms.

1. CENTRAL GOVERNMENT REVENUE

Central government revenue is the major revenue of total revenue at 87%; the remains are local government revenue, profit from state-enterprises and grants. The seven taxes collected by central government consist of 1) individual income tax, 2) corporate income tax, 3) value added tax, 4) specific business tax 5) stamp duty 6) excise tax, and 7) custom duties. The details of each tax presents as follows.

1.1 Individual income tax is imposed at progressive rates between 10% and 37% on taxable income for individual residing in Thailand for more than 180 days in any tax year (Table 2). In addition, income from financial asset is taxed at the rate of 15%.

Table 2 Individual income tax rates

Taxable income (Baht) ¹	Tax rate (Percentage) ¹	Proportion of Workers ²	Tax revenue ^{2,3}
Less than 0	No Tax	83.96%	-
0 - 100,000	Period exemption	4.64%	00.03%
100,000 - 500,000	10	09.89%	13.46%
500,000 - 1,000,000	20	01.05%	21.04%
1,000,000 - 4,000,000	30	00.43%	40.15%
Over 4,000,000	37	00.03%	25.32%

Source: ¹ Fiscal Policy Office, Ministry of Finance

² The Revenue Department in 2006

Remark: ³ Including taxes from financial assets

1.2 Corporate Income tax is normally applied to the net profit at 30%. However, there are reduced rates for small and medium-sized enterprises (SMEs) and other qualifying organizations (Table 3). The highest rate applied is to petroleum companies at the rate of 50% of net income.

1.3 Value added tax (VAT) was introduced on 1st January, 1992 to replace the business tax. It is a sales tax for normal goods and services at a rate of 7%. Exports to some destinations are exempt at 0%.

1.4 Specific business tax is a sales tax for businesses with value added which are difficult to define, such as financial and real estate businesses. The tax rate ranges between 2.5% and 3.0% of gross receipts for the central government and 10% for the local government.

Table 3 Corporate income tax rates

Taxpayer	Tax base	Rate (%)
1. Small company with paid up capital less than 5 million Baht at the end of each accounting period	Net profit not exceeding 1 million Baht	15
	Net profit over 1 million Baht up to 3 million Baht	25
	Net profit exceeding 3 million Baht	30
2. Companies listed in Stock Exchange of Thailand (SET)	Net profit for first 300 million Baht	25
	Net profit for the amount exceeding 300 million Baht	30
	Remark; both for first five accounting periods after listing	
3. Company newly listed in Stock Exchange of Thailand (SET)	Net profit	25
4. Company newly listed in Market for Alternative Investment (MAI)	Net profit for first five accounting periods after listing	20
5. Bank deriving profits from international Banking Facilities (IBF)	Net profit	10
6. Foreign company engaged in international transportation	Gross receipts	3
7. Foreign company not carrying on business in Thailand receiving dividends from Thailand	Gross receipts	10
8. Foreign company not carrying on business in Thailand receiving dividends from Thailand	Gross receipts	15
9. Foreign company disposing profit out of Thailand	Amount disposed	10
10. Profitable association and foundation	Gross receipts	2 or 10
11. Regional Operational Headquarters (ROH)	Income from servicing subsidiaries of ROH	10
	Interest received from subsidiaries of ROH and Royalty fee research and development (R&D) received from subsidiaries, branch or other company	

Source: Fiscal Policy Office, Ministry of Finance

1.5 Stamp duty is a form of taxation on documents and transactions which require stamps to be affixed on. These are mainly government forms, legal contracts and other instruments. Stamp duty is set up at various rates ranging from 1/1000 baht to 100/1000 baht depending on the class of the document.

1.6 Excise tax is a sales tax for selectively restricted commodities such as petroleum, tobacco and some luxury goods. This tax, which is an instrument to promote social responsibility, is categorized into the following four groups:

- Harmful products and services for public health
- Against moral products and services
- Luxury products and services
- Concessionary products and services by the government

1.7 Custom duties are collected from prices of cargoes, insurances, and freight (CIF). According to the Harmonized System, their rates range between 0% and 10%

depending on production processes, with the exception of automobiles at a rate of 80%.

The three targeted production processes are:

- a) 1% for raw materials and inputs not produced locally
- b) 5% for semi-finished products
- c) 10% for finished products, products requiring extra protection, and luxury goods

The seven types of taxes mentioned above are collected by three departments under the Ministry of Finance.

- a) The Department of Revenue is responsible for individual income tax, corporate income tax, petroleum tax, VAT, special business tax, etc.
- b) The Department of Excise collects all excise tax.
- c) The Department of Customs administers import and export duties.

2. LOCAL ADMINISTRATIONS' REVENUE

Local governments heavily rely on obtaining a share of central government's tax revenue to fund its activities. There are over 7700 local governments in Thailand which are categorized as follows:

- Bangkok Metropolitan Administration (province)
- Provincial Administrative Organization (province)
- Pattaya City (amphoe²)
- Municipality (province, amphoe, and tambon³)
- Tambon Administrative Organization (tambon)

The primary sources of local administrations' revenue are local levied taxes, surcharges on central government tax, shared revenue, revenue transfers, and government grants.

2.1 Local levied taxes are the direct taxes which is administrated and collected by the local administration. These can be classified into two groups of organizations which collect taxes, namely:

² It is like a district, the second level administrative subdivision of Thailand, subdivision from province.

³ It is the third level local government below amphoe.

- Municipality (Tessaban), Tambon Administrative Organization (TAOs), Bangkok Metropolitan Administration (BMA) and Pattaya City. These taxes are land and building tax, land development tax, slaughter tax, and fee, fine and license.
- Provincial Administrative Organizations (PAOs). These taxes are hotel tax, petrol stations tax, and retail tobacco tax.

2.2 Surcharge on government tax is usually an additional 10% on top of government tax less 5% for collection expenditure. This tax is added on VAT (added 11.11%), excise tax, retail liquor license, gambling license, and gambling tax on horse racing (added 2.5%).

2.3 Shared revenue is collected by the government and shared with the local administration, which includes:

- A 5% share of VAT collected in very province except BMA. This share is transferred to PAO and then transferred to all local administrations according to the Decentralization Act.
- 60% of mineral and petroleum tax distributed by the source of revenue

2.4 Revenue transfer is collected by government agencies and transferred to local administrations by the source of revenue. These transfers are motor vehicle tax, motor registration fees and real estate registration fees.

Moreover, other departments in other ministries are empowered to levy other related charges or fees. For instance, the department of mineral resources collects royalties for mineral exports and the Department of Land collects registration fees on transfer of land ownership.

2.1.2 TAX REFORM, PRESENT SITUATION AND PROBLEMS

1. Major tax reforms

Taxes in Thailand have been reformed several times but there are only three major reforms since the 1990s. These reforms relate to 1) Income tax, 2) Value added tax and 3) customs tariff. The tax rates of income taxes have been decreased from the highest level at 55% to 37% of individual income and decreased from 50% to 30% of corporate

income. The second reform is the change from business tax to value added tax in 1992. For the third reform, the Thai government applied a three-rate framework of custom duties from WTO in 2002.

2. Present circumstance and issues for tax administration

2.1 Low tax base

The tax revenue collected by the Thai government is relatively low in comparison with other countries (Table 1). The effective tax rates of the Thai government are less than the medians of three groups of countries. This is looked into the research question. Figure 1 presents the change in Thai effective tax rate. Two significant drops in the effective tax rate since 1990 were caused by 1) the imposition of value added tax in 1992, and 2) the 1997 financial crisis. However, after recovering from the crisis, the effective tax rate dramatically increased to the previous stage.

Analysis of the data identify that the causes of the problem are 1) comparatively low statutory tax rates and 2) the ineffective tax administration. The Thai effective tax rate was significant less than other developing countries' from 1996 to 2001 (Table 1) because the Thai economy was seriously suffering from the 1997 crisis. Thus the low tax revenue during this period was due to the external economy and the problem of ineffective tax administration is not as serious as previously thought. However, with the level of country development (new industrialize country), the effective tax rate should not be less than the median of the developing group's. The reviewed data presented below show that Thailand's statutory tax rates are less than other countries' tax rates and there is high tax evasion.

The low tax revenue can be explained as both low tax rate and indirect impacts. By considering the main taxes of Thai central government, Thailand's VAT rate (7%) is less than the average VAT of 59 countries at 16.7% (world-wide.com), or the average indirect tax rate of 104 countries at 15.7% (KPMG.com). This significant difference in tax rate (around 9%) can create sufficient tax revenue for the government and push Thailand's effective tax rate to be possibly higher than the median of other developing countries.

Tax exemption and poverty indirectly causes the comparatively low tax rate. The numerous tax exemptions and tax evasion are mentioned to be the reasons of the low tax base of the Thai government (Sujjapongse, 2005). Over 50 contents of both tax exemptions and deductible expenses lead to a smaller tax base. However, those exemptions cannot be powerful without poverty. Poverty and the income disparity are the primary problems for the Thai government. Per capita *GDP* of Thailand at \$2,539 is smaller than the average of the World and the United States at \$6,570 and \$39,883 respectively (source from UNDP, 2004). In addition, Thailand's Gini coefficient is 0.493 above 0.4; this implies that there is high inequality of income distribution in Thailand. According to the filing of the Revenue Department, there were 5.7 million taxpayers for individual income tax out of 35.7 million people in employment in 2006 (16.03%). This data corresponds with the analysis from the report of the 2004 household socio-economic survey of the whole country by National Statistical Office which shows that only 15.71% of the workforces are taxpayers (Figure 2). Around 84.29% of labor force receives an annual income of less than the threshold of the individual income tax of 100,000 baht. This percentage includes taxpayers who have reached the threshold level but do not reach the 100,000 baht level after deducting tax exemptions. The poverty and tax exemptions result in a potential 61.74% of total individual income being lost. These imply that not only lessening the tax exemptions can promote the tax revenue but also alleviate poverty by providing the government more funding for public services.

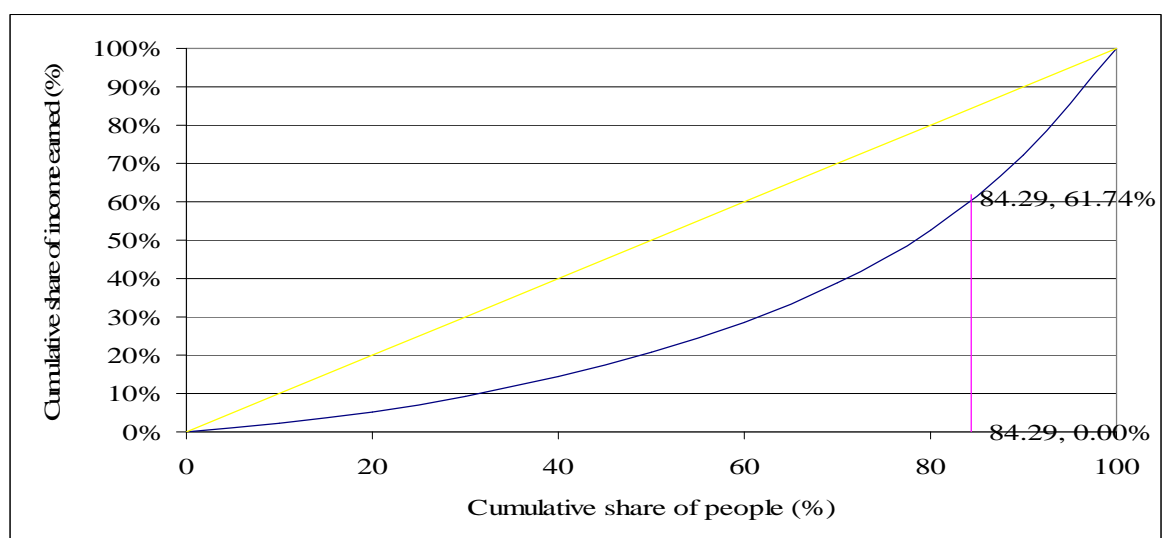


Figure 2 Lorenz curve diagram of Thai context in 2004

Source: Report of the 2004 Household Socio-Economic Survey Whole Kingdom, National Statistical Office, Ministry of Information and Communication Technology

The high amount of tax evasion is another cause of low tax revenue. The amount of Thai tax evasion was estimated by several researchers. The first is tax evasion of individual income tax; tax evaders were estimated at over 4 million of 10 million taxpayers (40%) (Sujjapongse, 2005). The second is tax evaders of corporate income tax; the surveying results present that for every 100 registered firms, another 16 firms were unregistered (Poapongsakorn, 2000). These 2 types of tax evasion represent the large proportion of tax evaders. If tax administrators can control the evasion well, not only will tax revenue increase, it will also help promote horizontal equity for the other honest taxpayers.

For these three causes of the low tax revenue problem, an integral solution is needed to solve the problem systematically. Some possible solutions include 1) a tax reform; this is a method to adjust tax rates to increase tax revenue. A tax reform must be considered under various conditions such as the four goals of tax reform; changes in tax evasion, circumstance of economy and fiscal policy, and expected government expenditure. 2) Effective budget allocation for the three main tax departments can drive the effective tax administration to the optimum point. This occurs under the assumption of diminishing returns of scale when marginal tax revenue is equal to marginal collecting cost in each department. 3) Reward incentives can be used to control the corruption and tax evasion in taxation, and 4) fiscal policies should be set up with an emphasis on an escape from poverty trap and an income disparity to increase the base income of the workforce.

2.2 Composition of tax revenue and tax burden from the direct and indirect taxes

As mention earlier, the majority of Thai tax revenue are collected from five main taxes. Figure 2 illustrates the average composition of tax revenue during fiscal years 1998 - 2003. In decreasing order of contribution, Value Added Tax is the largest share at 27%, followed by Excise Tax, Corporate income tax, individual income tax, custom duties, and other taxes. The contributing share of custom duties has gradually declined due to the Thai government entering trade liberalization commitments such as World Trade Organization, Asian Free Trade Area and other Free Trade Agreements. The smallest contributing share is other taxes collected by the local administration. Due to the small tax income earnings from local administration, the government issued a decentralised

strategy via tax reform policies to raise the share for the local government from 20% of the central government revenue in 2001 to over than 35% in 2006.

If indirect taxes, which are constant tax rates, are defined as effective regressive tax rates as opposed to progressive, then the tax burden is heavier on consumers than suppliers or producers who earn the income from selling goods and services. (Chernick & Reschovsky, 2000; Sujjapongse, 2005). Considering the tax burden issue begins with the composition of government revenue in terms of the direct and indirect taxes (Figure 3). The total government revenue comprises of indirect taxes (58%), direct taxes (30%) and not-tax revenue (12%). This highlights that the Thai government's revenue heavily relies on the indirect taxes, similar to other developing countries in Asia and Oceania (Table 4). Economists such as Sujjapongse, Chernick and Reschovsky believe the high indirect tax revenue increases income disparity. They believe that indirect taxes are regressive taxes for two main reasons: 1) there is a higher saving rate of the rich than the poor, so the poor are taxed at a higher ratio of their incomes than the rich (Creedy, 1998); 2) they only considered certain kinds of necessary goods, such as gasoline, which are consumed by the poor at similar amounts as the rich, thus the ratio of its tax to the poor's income is higher than to the rich (Chernick & Reschovsky, 2000). These reasons lead to the belief that the indirect taxes are regressive taxes and that their high burden on poor consumers will enlarge the income disparity.

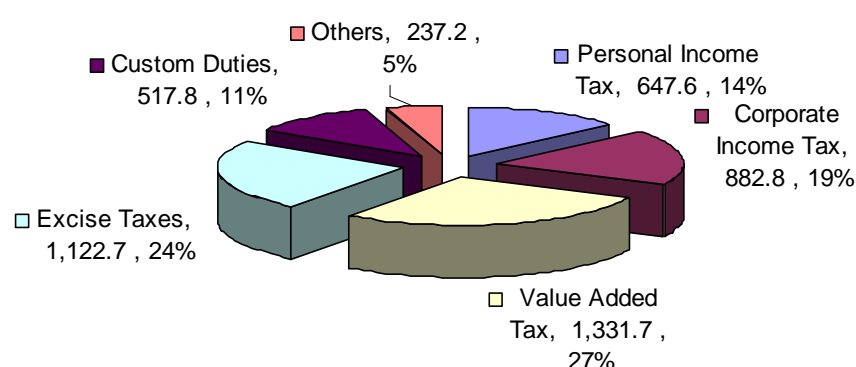


Figure 2 Composition of tax revenue (in percent). Fiscal years 1998-2003, Unit:

Billion of Baht, Percent

Source: Fiscal Policy Office, Ministry of Finance

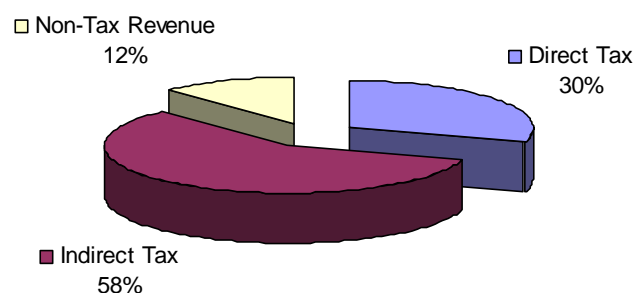


Figure 3 Share of Total Government Revenues (In Total) Fiscal Year 1998-2003

Source: Fiscal Policy Office, Ministry of Finance

Table 4 Composition of government revenue

Government revenue (1990-2002)	Direct Tax	Indirect Tax
Developed countries	63.3	28.6
Transitional economies	51.0	45.1
Developing countries	28.3	57.9
Asia and Oceania	34.1	60.4
Thailand	29.8	58.5

Note Average taken by median value of simple average.

Source: UNPAN Statistical Database

Source: Fiscal Policy Office, Ministry of Finance

However, a review by Creedy (1998) presents reasonable evidence arguing that indirect taxes are progressive. He argues against the smaller tax ratio due to higher savings of the rich, saying that multi-period consideration should be taken into account. Savings will be spent in the future, which will then be taxed at that point. Furthermore, the rich have to pay interest income tax, which is paid less by the poor with fewer savings. From this, it can be concluded that savings is not a reason to support that indirect taxes are regressive. Excise taxes for necessary goods, such as gasoline, are not set up to alleviate income disparity. They are set up to promote the social development. In isolation, certain types of indirect taxes are regressive but overall, indirect taxes are progressive. This is because food, the major share of goods consumed by the poor, is exempted from VAT, while many luxury goods are charged with both VAT and excise taxes. Thus poor consumers in Thailand pay much less indirect taxes than the rich. Whenever the overall indirect taxes are progressive, no matter what burdens of the indirect taxes are borne by consumers or earners, they help alleviate the income disparity.

3. Future direction of tax reform

Thailand's roadmap for tax reform has been in operation since the last financial crisis in 1997. The increase in tax revenue since then is a good developing sign (Figure 1). However, the goals of the tax reform are not to maximize the tax revenue but to consider carefully the following framework.

1. Achieving poverty alleviation and reducing income disparity
2. Promoting national competitiveness
3. Promoting social development
4. Furthering fiscal decentralization

This background of Thai taxation will be considered as the research question and relevant constrain in this research. The next section is the review of theory used in this research.

2.2 LITERATURE: MEASURING EFFECTIVENESS OF TAX COLLECTION

Low tax revenue is an interesting issue for many economists. This can be resolve by promoting the tax effectiveness. However, how can this effectiveness be measured? Effective tax administration of Transition Economies is measured and compared through the $\frac{\text{Effective tax rate}(E)}{\text{Statutory tax rate}(S)}$ ratio with the benchmark at the mature market

economies of the European Union. The research results suggest a positive correlation between the progress of the transition and the effective tax administration (Schaffer & Turley, 2000). However, it can be argued that this ratio presents the composition of tax base, after deducting tax exemption, to the total tax base without considering tax evasion. The effective tax rate is calculated from the tax revenue over tax base. Both the figure of the tax revenue and the tax base are based on legal records, so the calculation of the effective tax rate does not include loss in taxation from tax evasion. Thus the E/S ratio does not represent the true effective tax administration. In addition, poor citizens in developing countries have the tendency to spend more proportion of their income on tax-exempted food than in developed countries, therefore the E/S ratio of developing countries are usually lower than the developed countries'. This research will seek to find a method to measure the effectiveness of tax collection through the underground economy and tax evasion.

To measure the tax effectiveness, this research begins with the defined equation of the effectiveness of tax collection (Ef), which is calculated from the collected tax revenue (Tx) over the estimated total tax revenue including tax evasion (TE) in the underground economy as equation (1). Where i represents one type of the five main taxes;

$$Ef_i = \frac{Tx_i}{Tx_i + TE_i} \quad (1)$$

2.2.1 ESTIMATION FOR TAX EVASION

This review presents two methods for the estimation of tax evasion: tax evasion that has been detected by the auditors and undetected in the underground economy. The former method is called “Taxpayer Compliance Measurement Program (TCMP)” (Clotfelter, 1983) and the latter is the monetary approach of Tanzi (1983).

The TCMP is a simple statistical method which compares the amount of taxpayers or the value of reported income by taxpayers. The reported income will be classified into ‘tax due or underreported income’, ‘correct’, and ‘tax refund or overreported income’. The refund is defined as an unintentional error term, which should be equal on both sides of underreporting and overreporting. Therefore the unintentional error term on the underreported side is named as an error term reflecting a mistake. The tax due comprises of the error term reflecting a mistake and a deliberate evasion. If there is a significant difference between the tax due and the tax refund, it is assumed to be the statistical tax evasion as follow.

$$\%Tax\ evasion = \%Tax\ due - \%Tax\ refund \quad (2)$$

This estimated tax evasion is already included in the recorded tax revenue because the tax due has already been detected. Then this estimated tax evasion cannot represent the leak of tax revenue as in the equation (1). It could be said that the definition is different between tax evasion detected in the tax system and the undetected tax evasion in the underground economy. The tax evasion for this research will be focused only from that of the underground economy. The size of the underground economy can be estimated by direct and indirect methods. The direct method surveys both underground outputs and their demands for labor or expenditure. This method has an advantage as it goes into detail of each type of hidden activity. However, it is time consuming, costly and requires much manpower to conduct. This surveying method had been used during

1993-1995 in Thailand. The underground economy is estimated to be around 8 – 13 % of Thailand's GDP (Phongpaichit, Piriya-rangsarn, & Trirat, 2000). This is a good reference for comparison with the indirect estimation in this research.

The five indirect methods for estimating the underground economy comprise of the monetary approach (Tanzi, 1983), Labor force participation rate (Lemieux, 1994), Electricity consumption method (Kaufmann & Kaliberda, 1996; Lacko, 2000), Discrepancy Approach (Erard, 1997) and MIMIC model: Multiple Indicators, Multiple Causes model (Giles, 1999). Money, labor forces and electricity consumption variables are similar elements in both legal and illegal activities. Monetary approach, electricity consumption discrepancy approach and MIMIC model are used to estimate with secondary data while labor force participation rate needs surveying for the proportion of illegal labor forces. In the discrepancy approach, the underground economy is defined as the gap between an income-base and an expenditure-base of national account. This method is the easiest to arrive at an estimated outcome, but it has big weakness because of distortion. Both recorded income and expenditure do not contain hidden expenditure and income as taxpayers wish to evade direct and indirect taxes by underreported income and expenditure, respectively. As such, it cannot be said that the statistical discrepancy represents the size of underground economy as it is based on incorrect inputs. The MIMIC model is a statistical regression model which either use a mix of all or some of the other approaches depending on the researcher, to formulate indicators for this model. This research will consider three methods: electricity consumption method, monetary approach and the MIMIC model. Due to the limited budget and time for this research, these three are reasonable and practical methods and will be considered in detail to indicate the most suitable method for this research question.

The Monetary approach was first used by Cagan (1958). The underground transaction is assumed to rely on the currency (i.e. hard cash) for avoiding the auditing resource and destination of money. Monetary approach can also be divided into two methods; currency ratio comparison and currency demand model. The currency ratio (Currency in circulation: C to Demand deposits: D) is assumed to remain constant for any period (Gutmann, 1977). If there is excessive currency ratio over the minimum ratio which was calculated at WWII, it implies that the excessive currency is used in the underground economy. The estimated result of the underground economics of USA was around 9.4% in 1976. The currency ratio is adapted by Feige (1979). The assumption is that the

underground economy depends on big bank note multiply by the number of lifetimes of each bank note per GNP and at the minimum ratio of big bank note, it is assumed that there is no underground economy. Using this method, the underground economy of USA was estimated at 19.1% in 1976, 9.7% more than the result of Guttman. Their assumptions of a minimum ratio equating to no underground economy was heavily criticized by other economists. Feige (1989) then developed a benchmark by comparing formal currency ratio and informal currency ratio as $Y_u = Y_0 \frac{(C - k_0 D)}{(k_0 + 1)D}$, where k_0 represents the ratio of the stock of currency in the formal sector to the stock of demand deposits in the formal sector. However, this is still the unpopular constant ratio. In the same period, the currency demand model of Cagan was adapted by Tanzi (1983). In their models, the currency ratio at the state of no underground economy can be changed reasonably according to the circumstances of the economy. Both models are almost the same except the technique to estimate and the adding up ratio of wages and salaries to national income (WS/NI) in the Tanzi's model. The detail of Tanzi's model contains the following variables. The ratio of currency holdings (C) to money (defined as $M2$) is the dependent variable varying to an average income tax variable (T), the ratio of wages and salaries to national income (WS/NI), the deposits rate (R), real per capita income (Y), and error term (ε). Thus,

$$\ln \frac{C}{M2} = a_0 + a_1 \ln(1 + T) + a_2 \ln \frac{WS}{NI} + a_3 \ln R + a_4 \ln Y + \varepsilon \quad (3)$$

The expected correlate signs for first two variables are positive and the following two variables are negative. Tax rate is the key variable to estimate the underground economy and tax evasion because an increase in tax rate creates incentive for taxpayers to evade more tax. They have to hide their income by using more currency. Thus the relationship between currency and tax rate is positive (Clotfelter, 1983). Secondly, wages and salaries, which are the majority share of National Income, are paid by cash. Increasing wages and salaries requires more currency for payment. Thirdly, deposit rates have a direct effect on individuals by forcing them to make the decision of holding currency or saving it. High interest rate encourages people to save more money and hold less currency. The last variable, per capita income, represents the technology of bank transactions. Improved technology such as credit cards can reduce the incentive to hold currency. These are the reasons of expected sign of each relationship variables.

The process of estimation of the underground economy and tax evasion begins with the calculation of the difference in currency between general holding for both legal and illegal transactions (\hat{C}) at recorded tax rate and holding for only legal transactions ($\hat{\hat{C}}$) at zero tax rate; they are shown as equation (4) and (5). When tax rate is equal to zero, it is assumed that there is no tax evasion because there is no need to evade tax. Evading tax need some specific costs such as distortion costs.

$$\hat{C}_i = M_2 \cdot \exp(a_0 + a_1 \ln(1+T) + a_2 \ln WS/NI + a_3 \ln R + a_4 \ln Y) \quad (4)$$

$$\hat{\hat{C}}_i = M_2 \cdot \exp(a_0 + a_1 \ln(1+0) + a_2 \ln WS/NI + a_3 \ln R + a_4 \ln Y) \quad (5)$$

This difference in currency or the excessive currency ($\hat{C} - \hat{\hat{C}}$) is defined as illegal money. This can be converted into the underground economy by multiplying the difference by the velocity of legal money (v). Legal money is calculated by subtracting the illegal money from narrow money ($M1$).

$$\text{Legal money} = M_1 - \text{illegal money} = M_1 - (\hat{C} - \hat{\hat{C}}) \quad (6)$$

$$v = \frac{GDP}{\text{legal money}} \quad (7)$$

$$\text{Underground economy} = (\hat{C} - \hat{\hat{C}}) \cdot v \quad (8)$$

The estimated underground economy was around 5.49% of GNP in 1976 and the underground economy had grown gradually since the mid-1960s. Tax evasion can be calculated from underground economy by multiplying by the effective tax rate.

$$\text{Tax evasion} = \text{Underground economy} \times T \quad (9)$$

Tax evasion in the United States, estimated by Tanzi, increased dramatically with a high acceleration from \$7.73 billions in 1976 to \$15.01 billions in 1980.

The idea of the MIMIC model begins with denoting the underground economy as a ‘latent’ variable. It then uses the derive method to calculate the latent variable from two regression equations: an indicator equation and a cause equation. Both equations vary according to each author. The MIMIC model, firstly, has been used to estimated the hidden economy by Frey and Weck-Hanneman (1984). They measure the hidden economy as the unobserved variable through the LISREL (liner interdependent structure

relationship) model, a generalization of the MIMIC. The causal equation contained four factors: the burden of taxation; the tax morality; the rate of unemployment; and the level of development of the economy. These panel data of OECD countries were constructed along with the two indicators, the growth rate of official real GDP and the participation rate of the labor market. Just like the DYMIMIC model of Aigner and et al (1988) was applied the lagged latent variable in the model and the model was trialed for the optimal causal and indicator variables. These two models, LISREL and DYMIMIC, are not used in this research because of the limited data of the participation rate in labor market. Without the labor market data, the MIMIC model will left only the monetary and National account data as the MIMIC model of Giles (1999). He set the money demand as the indicator of the underground economy (10) and the hidden economy ratio as the cause equation (11). Money demand ($M3$) depends on recorded income (Y_r), hidden income (Y_h), short term interest rate (R) and price level (P) while the hidden economy depends on Goods and Services Tax (GST), recorded income and price level.

$$M_t = \beta_0' Y_{Rt1}^\beta Y_{Ht2}^\beta R_{t3}^\beta P_{t4}^\beta \quad (10)$$

$$\left(\frac{Y_{Ht}}{Y_{Rt}} \right) = \alpha_1 + \alpha_2 GST_t + \alpha_3 \Delta \log Y_{Rt} + \alpha_4 \Delta \log P_t + \alpha_5 \Delta (\Delta \log P_t) \quad (11)$$

By substituting equation (11) into (10) and thereby cancelling out the derived hidden income variable (Y_{Ht}), it will become the MIMIC model. The next step is to estimate the output of the model, which can now be done without the hidden income variable or the latent variable. From this estimation, the hidden income is derived. The result shows the hidden economy is on average less than 9% of recorded GDP and varies between 6.8-11.3% from 1968-1994. There are several weak points in this model that should be considered. The first point is that M3 varies only with the supply side, such as foreign transferred money and M1, which is controlled by the Central bank. It is difficult to use M3 to explain the relationship between the underground economy and money. According to monetary approach assumption, when participants hide their transaction in the underground economy, they will switch from using bank transactions to currency transactions (D to C). The amount of money does not change in these transactions but the underground income rises. Another weakness is that many relationships of the variables in equation (11) are difficult to use to explain the cause of change in hidden income.

The last method is the electricity method by Lacko (2000). This model also contains the latent variable, but the electricity consumption is used as the indicator of the underground economy instead of the money variable. It is interesting to note that in this method, two types of tax rate variables are used in the model; individual and corporate income tax rates. This shows the different influences of each tax rate on evading incentives and provides a good explanation for the change in hidden economy for each tax. However, the electricity method cannot explain the change in the hidden economy from evading activities of other types of indirect taxes and there is no enough recorded data of electricity consumption in Thailand,

In conclusion, with the limited data base and the focusing at tax evasion, this research will rely on the Tanzi monetary approach because the other alternative methods focus at the underground economy, which may be declared transactions and income or/and taxed to laundered money.

Recent estimations of the underground economy and tax evasion are base on money approach of Tanzi. Three other monetary models adapting from Tanzi are: 1) Aslam (1998), 2) Hill and Kabir (2000), 3) Maurin (2006). These models can be examined for four main different points, as shown in Table 5, and their strengths and weaknesses will be considered for setting up the monetary approach model in the Thai context in the next chapter.

The first point is the difference in variables. Most variables refer to Tanzi's approach but some variables are adjusted and added up for each country. However, the main purpose of examining the tax evasion rate from the relationship between currency and tax rate remains the same. These variables can be categorized into five groups:

- *Group of money*: This represents the dependent variable. This contains *CFCA* - currency in circulation + foreign currency accounts, *C* - currency outside other depository, and *M2* - broad money.
- *Group of tax rate*: This is a key variable to estimate the tax evading activities. It contains T^T - Income tax rate for Tanzi, and $TGDP$ or $\frac{T^M}{Y^M}$ - an effective tax rate in terms of the ratio of total tax revenues to *GDP*, terms used by Aslam and Maurin, respectively.
- *Group of interest rate*: This contains *INT* and *R* - deposit rate.

- *Group of money transactions*: This contains WS - wages and salaries, NI - National income, Y^A - Growth rate of real GDP , and X - nominal personal expenditures
- *Group of additional detail*: This contains Y^T - per capita income for Tanzi, F - a measuring financial innovation and DUM - a dummy variable. The first two variables represent the technology of bank transactions.

The second point is that the methods used to estimate regression are either the long-run model or the short-run model. The third is the difference in velocity of money. The last is that the currency is estimated at equilibrium of demand and supply equations. All this important points will be considered to set up a new monetary model to estimate the underground economy and tax evasion of Thailand.

Table 5 Meta Analysis; comparison currency demand approach to estimate hidden economy and tax evasion

Year	Author	Variable	Method	Observation	Velocity	Results	Country
1983	Tanzi	$\frac{C}{M2} \left(T, \frac{WS}{NI}, R, Y \right)$	OLS	52 years	$V = \frac{GDP}{(M1 - im)}$	Underground economy 0.6-6% of GDP and tax evasion is 0-15 billion U.S. dollars	USA
1998	Aslam	$\frac{CFCA}{M2} (TGDP, INT, Y^A, DUM)$	OLS	39 years	$V = \frac{GDP}{CFCA}$	Underground economy is 29-53% of GDP and tax evasion is 2.11-6.95% of GDP	Pakistan
2000	Hill	$C(X, P, R, T, F)$	ECM	20 quarters	$V = 0.18 \times \frac{pT}{M1} \approx 2.7 - 3.6,$ $0.18 = \frac{NI}{T}$	Underground economy is 0.14-0.72% of GDP, tax evasion is 1.2-5.1% of total tax revenue	Canada
2006	Maurin	Demand: $\frac{C}{P} \left(R, \frac{Y^M}{P} \right),$ Supply: $\frac{Y^M}{P} \left(\frac{C}{P}, \frac{T^M}{Y^M}, \pi \right)$	SCVAR	27 years	$V = \frac{YP}{C_R}$	Hidden economy is 14-36% of GDP	Trinidad & Tobago

3 ESTIMATION OF THE EFFECTIVENESS OF THAI TAX COLLECTION

3.1 INTRODUCTION

Tax and grants are the resources of government revenue. If the government expends collection costs effectively, they can collect optimum tax revenue with low tax evasion. For example, in the case of a highly effective tax collection, a marginal tax yield from the marginal tax collection costs is low. The government may not need to invest too much into tax collection effort. On the other hand, with an ineffective system of tax collection, marginal tax yield from the tax collection effort will be higher. In this case, the government can devote additional budget to improve its tax collection. These are the reasons why measuring the effectiveness of tax collection is essential.

This chapter presents a model developed for estimating the effectiveness of Thai tax collection. It comprises of two main sections aside from the introduction and conclusion. The first section discusses a model for estimating the tax effectiveness based on three groups of equations, i.e. tax effectiveness equation, demand and supply for currency equations, and legal effect of tax rate equations. The demand for currency equation is adapted from Tanzi's monetary approach, which is used for estimating tax evasion. The second section comprises of results and discussion. It covers three topics: the first topic is a comparison of the results obtained from Tanzi's approach with those obtained from the adapted model in the second section; the second topic is the development of tax collecting capacity; and the third topic is a summary of issues for future study.

3.2 MODEL

The effectiveness model contains the effectiveness equation, the demand and supply for currency equations and the legal effect of tax rate equations. The demand and supply equations are used to estimate tax evasion. An increase in tax rate does not only give raise to tax evasion but also affects negatively on the economy. This effect is defined as the legal effect for this research. After tax evasion is estimated from the last two groups of equations, the effectiveness equation will convert tax evasion into the tax effectiveness.

3.2.1 EFFECTIVENESS EQUATION

The effectiveness of tax administration is measured by the ratio of effective tax rate to statutory tax rate (Schaffer & Turley, 2000). This method makes an argument concerning only tax exemptions and omits tax evasion. For example, people in poor countries have a tendency to expend a larger proportion of their income on food without value added and excise taxes than people in developed countries. Thus the effectiveness of poor countries, calculated from the above ratio, is less than one of developed countries. The new effectiveness equation for this research is established with tax evasion as the key variable.

The effectiveness of tax collection (Ef) is measured by comparing the ratio of recorded tax revenue (Tx) to total potential tax revenue; the recorded tax revenue plus tax evasion (TE) in the underground economy. The full capacity of the tax effectiveness is equal to 1 when there is no tax evasion as in the equation (12). In addition, to examine the weakness in tax collection, the effectiveness will be estimated in five main taxes (i) of Thai government revenue; individual income tax, corporate income tax, value added tax, excise tax and custom tariff.

$$Ef_i = \frac{Tx_i}{Tx_i + TE_i} \quad (12)$$

3.2.2 DEMAND AND SUPPLY FOR CURRENCY

According to the literature in chapter 2, tax evasion can be estimated by the TCMP method and Tanzi's monetary approach. In the TCMP method, tax evasion is detected by tax auditors and included in the tax revenue, so the TCMP method presents a different estimate of tax evasion from equation (14). Although this method is not appropriate for measuring the overall effectiveness of the tax departments, it is good for measuring the individual performances of tax auditors. An example of calculation and the performance indicator will be presented in the results and discussion section. However, the majority of this research will focus on an adapted model from Tanzi's monetary approach, which is used to estimate tax evasion in the underground economy and it is assumed that this tax evasion is not included in tax revenue. Over time, his approach has been extensively used to estimate tax evasion for many countries and in adapting this approach, each researcher introduced some changes to suit an individual

countries' context. Thus the model in this research is a synthesis of the strengths of various models, drawing from two in particular: Lacko (2000) and Maurin et al (2006). Lacko's model contains two tax rate variables, while Maurin et al contains a simultaneous equation structure of currency demand and supply.

Lacko's technique estimates the effectiveness of each tax by looking at electricity demand. The electricity consumption model contains two tax rate variables; individual and corporate income tax rates. These are used to estimate electricity costs and the underground economy. Each tax rate presents the relationship between income from the underground economy and the electricity costs. The individual income tax applies to the income after deducting tax exemptions while the corporate income tax applies to the profit of firms. So even if the initial income of an individual and corporate firm are numerically equal, the resultant tax base amount will be different, and applying one percent of tax rate will result in a different amount of tax revenue collected and this creates different incentives to evade tax in the underground economy. This technique will be used to estimate each tax evasion of the five main taxes.

The technique Maurin et al uses directly estimates the volume of currency from a simultaneous equation system. This is an advancement of Tanzi's approach which estimates tax evasion through the ratio of currency to broad money. In this work, both Tanzi's and Maurin's approach are applied and the estimates are compared.

Certain changes are introduced for this work when adapting the above approaches:

1. The supply for currency equation in this work is different from Maurin's supply equation. The explanation of the supply equation by Maurin is ambiguous and so a new supply equation is established to explain the equilibrium of the demand and supply for currency. The currency demand equation is derived from people's behavior and the supply equation in this research should be derived from financial institutes' behavior. These firms offer a deposit rate for people to make decisions on holding currency. However, the deposit rate is not considered directly from the amount of currency but from the amount of deposits. Interests on deposits are costs for the financial institutes; therefore the banks' demand for deposit is related inversely with the deposit rate as Figure 4. Following this definition, broad money is equal to currency plus deposits ($M2 = C + D$) and thus the demand for deposits can be considered as the supply for currency.

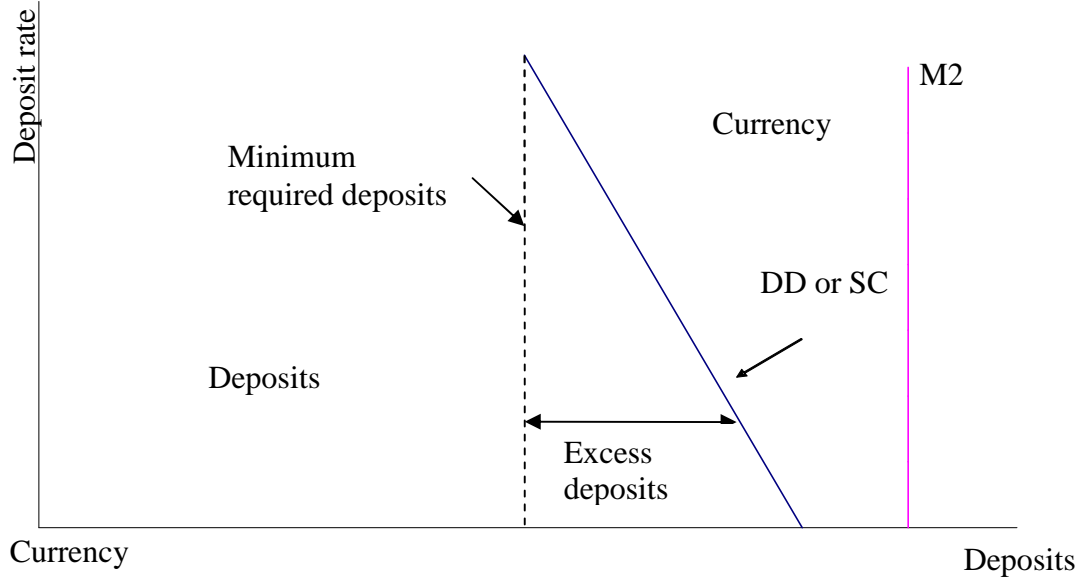


Figure 4 Demand for deposit or supply for currency

Moreover, money is an instrument of the central bank for controlling economic growth. The central bank considers narrow money as a key variable in the transaction approach ($v = \frac{GNP}{M1}$). The changes in narrow money can influence both broad money and currency. Thus the currency supply equation in this research may contain the deposit rate, deposits or currency, loan rate, loans and narrow money variables. These variables will be tested for the best estimation.

2. The model should be analysed as a long-run model. Due to the process of the estimation, the long-run model absorbs the complete information from any changes in tax rate and reports the results at a stable state. The short run model on the other hand shows delayed or shocked effects of changes in the tax rate in each period. For example, the comparison between the long-run and the short-run models are presented as follows;

The long-run model can be assumed as the short form of C and T .

$$C_t = \alpha + \beta T_t + u_t \quad (13)$$

The error term (u_t) is assumed to be autoregressive.

$$u_t = \rho u_{t-1} + v_t; \rho < 1; \quad (14)$$

The short-run model can be derived as an autoregressive model.

$$(C_t - \rho C_{t-1}) = \alpha(1 - \rho) + \beta(T_t - \rho T_{t-1}) + v_t \quad (15)$$

According to the process of the estimation of Tanzi, tax rate is set at zero; $T = 0$, for all period t . Results of estimated C from the long-run model will be constant at α for all period t while the short-run model estimates varied C in each period t as below equations. At period 1 of the short-run model, estimated currency does not absorb all information and this is shown as the error term in the result. When citizens obtain more information about the change in tax rates, the error term will decline and value of currency will tend to α at period infinity. This is an example of delayed effect.

$$t = 1, \quad C_1 = \alpha + (\rho C_0 - \rho\alpha - \beta\rho T_0) = \alpha + \rho u_0$$

$$t = 2, \quad C_2 = a(1 - \rho) + \rho(a + \rho u_0) = a + \rho^2 u_0$$

$$t = 3, \quad C_3 = a + \rho^3 u_0$$

$$t = \infty, \quad C_\infty = a + \rho^\infty u_0 \rightarrow a$$

Error Correction Mechanism (ECM) is another form of a short-run model. Its error term distributes around the constant α and tends to α at period infinity. The long run-model has the advantage of providing an estimation in a stable state as the error term used in the model has no time lag effect.

3. The velocity of money, used to convert illegal money to underground economy, should be calculated from broad money ($M2$). The velocity by Tanzi is calculated from the ratio of recorded economy (GDP) to legal money (MI - illegal money). This process omits the illegal money and bank transactions such as cheque, paying by debit or credit card or bank transfers. The bank transactions are defined as the legal transactions, which can be detected the sources of money. The bank transactions and the illegal money are circulated in the recorded economy and participate in producing not only the legal money as in Tanzi's approach. Without income from the underground economy or the bank transactions, which are used to buy goods and services in the recorded economy, the recorded economy cannot be maintained the same level by the circulation of the legal money alone. This is the reason why the broad money, which contains legal money plus both the illegal money and the bank transactions as deposit transaction, is more appropriate for calculating the velocity of money. The final point of the velocity is that the effective tax rate is calculated from tax revenue over tax base (TB) of each tax

and so to convert the underground economy into tax evasion, the underground economy must be based on the tax base of each tax. Thus the definition of the velocity is the ratio of tax base over broad money; $v = \frac{TB}{M2}$

4. There is a negative relationship between tax rate and currency, which is defined as the legal effect. According to Tanzi's approach, the relationship between tax rate and currency is positive because an increase in tax rate creates an incentive for taxpayers to evade tax by using currency to conceal their incomes. This is defined as the illegal effect. The negative relationship is not considered in Tanzi's model. By considering the macro economy, tax rate is a negative multiplier for the economic system. For example, gross domestic production will increase when a government reduces the tax rate and currency, which is used as mediums of transactions in the economy, should increase too. The net result of the legal effect and the illegal effect of tax rate, as derived from the currency demand and supply equations, can be used to indicate the tax evasion effect of the tax rate.

After considering all the mentioned issues, the currency demand and supply equations are presented as follows;

Currency Demand equation:

$$\ln \frac{C}{P} = \alpha_0 + \alpha_1 \ln(1 + T_{ii}) + \alpha_2 \ln(1 + T_{ci}) + \alpha_3 \ln(1 + T_v) + \alpha_4 \ln(1 + T_e) + \alpha_5 \ln(1 + T_c) \\ + \alpha_6 \ln\left(\frac{WS}{P}\right) + \alpha_7 \ln(R) + \alpha_8 \ln(Y) + \alpha_9 \ln\left(\frac{M2}{P}\right) + \alpha_{10} \ln\left(\frac{GDP}{P}\right) \quad (16)$$

Currency supply equation:

$$\ln \frac{C}{P} = \beta_0 + \beta_1 \ln(R) + \beta_2 \ln\left(\frac{M1}{P}\right) \quad (17)$$

The equation (16) and (17) are estimated by Generalized Method of Moments (GMM). The reason for choosing this method is that the method is appropriate to estimate with the unknown form of heteroskedasticity and/or autocorrelation problems. This is the correlation between some of the right hand side variables and the error terms of equation. This estimator in GMM works to minimize both heteroskedasticity and

autocorrelation. As the mentions before the Tanzi's model should be estimated as the long run model. Although the GMM could minimize the autocorrelation of currency demand equation, it could not help so much with the other equations which most variables are I (1). This is the conflict of interest between Tanzi's technique and spurious regression. This is a weakness that it could not be made the perfect estimation. Thus, this research was designed to work in the long run model and leaved the simple macro economic variables using around the world in question that they may be spurious regressors.

To examine the best model for estimating the underground economy and tax evasion, each variable will be tested for the highest value of adjusted R-squared and the lowest sum of squared error of regression. After testing the significance of variables, broad money (M2) is excluded from the demand equation. The estimation outputs of currency demand and supply equations are presented below.

Currency Demand equation;

$$\ln \frac{C}{P} = -0.7188 \ln(1 + T_{ii}) + 0.3238 \ln(1 + T_{ci}) + .6074 \ln(1 + T_v) + 0.2908 \ln(1 + T_e) \\ (-2.759)** \quad (1.176) \quad (2.599)** \quad (1.459) \\ + 0.3761 \ln(1 + T_c) + 1.885 \ln\left(\frac{WS}{P}\right) - 0.1862 \ln(R) - 2.646 \ln(Y) + 1.512 \ln\left(\frac{GDP}{P}\right) \\ (2.466)** \quad (3.542)*** \quad -4.090)*** \quad (-3.027)*** \quad (2.598)**$$

Adjusted R-squared = 0.9822

Durbin-Watson stat = 2.185

Currency supply equation:

$$\ln \frac{C}{P} = -0.9639 + 0.05520 \ln(R) + 1.067 \ln\left(\frac{M1}{P}\right) \\ (-5.999)*** \quad (4.7756)*** \quad (59.95)***$$

Adjusted R-squared = 0.9848

Durbin-Watson stat = 0.5419

The independent variables can explain the change in the dependent variables of both the demand and supply equations well. Most coefficients present the correct signs of the relationships according to the reviewed assumption that the relationship between tax

rate and currency is positive. Only the coefficient of individual income tax rate variable presents a negative sign. This problem can be explained with the legal effect, which influences the currency more than the illegal effect of Tanzi's approach. Thus after estimating the size of the legal effect from the legal equations, this leads to indicate the illegal effect from the total effects of the currency demand and supply equations.

3.2.3 MACROECONOMIC MODEL FOR ESTIMATING THE LEGAL EFFECT OF TAX RATE

The process for estimating the legal effect begins with estimating the simple macroeconomic model from the aggregate demand and then examines the link between macro data and the currency. The macroeconomic equations are presented in 6 Appendix 1: estimation output of the model. Subsequently, expenditures are chosen to be tested for correlation with the currency. The results of the correlation test between currency and expenditures are presented in Table 6.

Investment and import expenditures are poorly correlated with currency. In other words, both expenditures have a tendency to use bank transactions more than currency. Moreover, the five main taxes affect currency in the form of disposal income. The legal effect of the tax rate will focus on significant transactions (ST) to the currency. From the explained results in the table, the significant transaction will be $PC+G+X-TXII-TXCI-TXV-TXE-TXC$, which presents the most significant correlation in the last row of Table 6.

Another interesting point of Table 6 is that GDP and ST correlate with $M2$ at higher rate than C . On the other hand, citizens do not make spending decisions solely based on the currency in their pockets but also considered their total money ($M2$) including their saving, credit or loan from the banks. This point supports the velocity of money based on $M2$ as mentioned before.

After estimating the entire system of equations in the effectiveness model, it can be used to estimate the effectiveness of tax collection following the process shown in section 7 Appendix 2: Mathematical procedure of tax effectiveness.

Table 6 Correlation between money and expenditures

	C	M1	M2	$\frac{(C_t - C_{t-1})}{C_{t-1}}$	$C_t - C_{t-1}$
GDP	0.9731	0.9691	0.9865	-0.1009	0.2601
PC	0.9820	0.9803	0.9915	-0.1060	0.2615
I	0.7655	0.7781	0.7755	-0.0612	0.2202
G	0.9844	0.9810	0.9921	-0.1204	0.2508
X	0.9815	0.9860	0.9862	-0.1559	0.2113
M	0.9657	0.9800	0.9643	-0.1595	0.2026
PC+I	0.9397	0.9431	0.9497	-0.0937	0.2561
PC+G	0.9831	0.9811	0.9923	-0.1085	0.2599
PC+G+X	0.9868	0.9883	0.9936	-0.1348	0.2346
PC+G+X-M	0.9835	0.9726	0.9980	-0.1078	0.2598
PC+G+X+M	0.9826	0.9883	0.9866	-0.1434	0.2246
PC+G+X-TXII-TXCI-TXV-TXE-TXC	0.9873	0.9879	0.9940	-0.1373	0.2317
$\frac{(C_t - C_{t-1})}{C_{t-1}}$	-0.0009	-0.0303	-0.1092	1.0000	0.8871
$\frac{(GDP_t - GDP_{t-1})}{GDP_{t-1}}$	-0.4432	-0.3808	-0.4855	0.1334	-0.1365
$C_t - C_{t-1}$	0.3639	0.3360	0.2598	0.8871	1.0000
$GDP_t - GDP_{t-1}$	0.4420	0.5042	0.4039	-0.0496	0.0655
$PC_t - PC_{t-1}$	0.5829	0.6299	0.5329	0.0467	0.2065
$G_t - G_{t-1}$	0.6209	0.6676	0.6015	-0.1071	0.1210

3.3 RESULTS AND DISCUSSION

In this section we will discuss three main issues comprising of 1) performance indicators by applying the TCMP method, 2) a comparison of the results between the adapted model and Tanzi's monetary approach and 3) the development of the Thai tax capacity and the effectiveness of the Thai tax collection system.

3.3.1 PERFORMANCE INDICATORS BY APPLYING THE TCMP METHOD

The tax evasion rate estimated by the TCMP method is presented in Table 7. According to the secondary data from the revenue department of Thailand, only corporate income tax data suits the use of estimating tax evasion by the TCMP method. Tax auditors classify the reported corporate income into four groups: 1) claimed tax refunds; 2) non-refunded or correct tax amount paid; 3) tax due; and 4) reduced deficit. Taxes from the third and fourth groups are the underreported income taxes or total tax evasion. The reduced deficit is defined as the difference in distorted deficit and true deficit. This can be used to reduce tax when companies begin to make profit in the future. In the first

period of years, total tax evasion was easily audited and it shows the high tax evasion at 30.25% and 16.82% in 2006 and 2007 respectively. Subsequently, the tax evasion rate decreased to 7% at the end of 2006. This cycle repeats again in 2007 but the evading ability of taxpayer became more complicated. By considering the tax evasion rates in July of both years, we see that they are almost equal in July, although they were very different in January.

The low tax evasion rate can imply both positive and negative conclusions. The low tax evasion rate is either a result of highly effective audits or a result of ineffective audits which lead to less detection of tax evasion and thus there is more tax evasion hiding in the underground economy. Although the TCMP method may not be appropriate for estimating the overall effectiveness of tax collection, the TCMP can be used as an individual effectiveness indicator of tax auditors.

To measure the individual tax auditor's performance, two indicators should be measured and calculated together. The first indicator is the ratio of an individually detected summation of erroneously reported tax (*IDS*) to an individual's salary (*IS*). The second indicator is calculated by applying the TCMP to individual auditors to estimate the individually detected tax evasion. The tax evasion indicator is equal to the ratio of individually detected tax evasion (*IDTV*) to an individual's salary. Next, the first indicator is set to have a higher weighted importance (*WI*) than the second indicator in a ratio of 2:1. There are 3 reasons for each issue are as follows: 1) The first indicator presents a general duty of tax auditors to audit both underreported and overreported tax, 2) The second indicator presents a high effort to audit tax evasion and gain more revenue for the government and 3) if both indicators are of the same weighted importance, some auditors may only audit for underreported taxes for the highest performance score (*PS*). When underreported tax is more than overreported tax, tax auditors cannot gain a higher performance score by detecting overreported tax as this will be cancelled out when combining the two indicators if both indicators were given the same weighted importance. Thus the different-weight setting can create the incentive for auditors to audit both the highly and lowly declared incomes. The performance score equation is presented as follow:

$$PS = WI_1 \times \frac{IDS}{IS} + WI_2 \times \frac{IDTV}{IS} \quad (18)$$

Table 7 Estimated tax evasion in Thai tax system by TCMP

Month	% accumulated declared tax of total corporate income tax revenue			
	Total tax evasion	Correct	Unintended tax evasion (due to error)	deliberate tax evasion
Jan-06	58.00%	42.00%	27.75%	30.25%
Feb-06	56.59%	43.41%	29.93%	26.65%
Mar-06	50.71%	49.29%	36.26%	14.45%
Apr-06	50.49%	49.51%	36.47%	14.03%
May-06	51.17%	48.83%	35.56%	15.60%
Jun-06	51.41%	48.59%	35.41%	16.01%
Jul-06	50.68%	49.32%	36.26%	14.42%
Aug-06	49.18%	50.82%	37.98%	11.20%
Sep-06	47.84%	52.16%	39.68%	8.16%
Oct-06	47.76%	52.24%	39.68%	8.08%
Nov-06	47.44%	52.56%	39.95%	7.49%
Dec-06	47.14%	52.86%	40.14%	7.00%
Jan-07	49.62%	50.38%	32.80%	16.82%
Feb-07	46.64%	53.36%	35.51%	11.14%
Mar-07	46.58%	53.42%	35.39%	11.18%
Apr-07	46.87%	53.13%	33.94%	12.93%
May-07	46.96%	53.04%	33.86%	13.09%
Jun-07	46.93%	53.07%	33.78%	13.15%
Jul-07	46.90%	53.10%	33.81%	13.08%

Remark: This table is calculated from raw data of the revenue department

These performance indicators are only useful for comparing tax auditors exposed to the same conditions such as auditors in the same group, same responsibility area or in the same year. They cannot be used to compare the individual performance between two years or two departments because the behaviors of taxpayers will then be different.

The next section will focus on the estimated results of Thai tax evasion and the effectiveness of Thai tax collection (Table 8). The results of the tax evasion will be compared between the adapted model and Tanzi's monetary approach. The explanation of changes in the effectiveness of the Thai tax collection system and tax capacity will then be described.

3.3.2 COMPARISON OF THE RESULTS BETWEEN TANZI'S MONETARY APPROACH AND THE ADAPTED MODEL

The Thai hidden economy was estimated to be an average of 71.0% of Thailand's *GDP* for the years 1990-1993 when calculated indirectly by the electricity consume method (Schneider, 2005) and between the range of 8-13% of *GDP* when calculated by the direct survey method (Phongpaichit et al., 2000). The underground economy estimated in Phongpaichit's research includes other illegal activities besides tax evasion such as

gambling and prostitution. Phongpaichit also estimates the tax evasion of that using currency to conceal route of transaction, giving bribes and tax corruption by tax officials. This paper's research however does not consider other illegal activities and only considers tax evasion of using currency to conceal route of transaction when estimating the underground economy. With the differences in the definitions of the underground economy and tax evasion, it is difficult to compare results between this research and Phongpaichit's. Thus, this research will focus on the comparison with the results of Tanzi's approach.

By comparison between the estimated tax evasion from Tanzi's approach and the adapted model in Table 8, four differences can be distinguished: 1) The adapted model estimates tax evasion more precisely into the five main taxes; 2) The large difference between the total estimated tax evasion rates of each method; 3) The different tax evasion behaviors during the 1997 economic crisis and; 4) The reverse long term tendencies between the tax evasion rates of both methods.

Table 8 Summary and comparison the results with Tanzi's approach

	%hidden economy or %tax evasion						%Total tax evasion of total tax revenue	%Total tax evasion of GDP
	Tanzi	ii	ci	v	e	c		
1983	51.34%	4.32%	8.45%	13.00%	18.46%	14.97%	13.50%	1.74%
1984	60.05%	6.22%	9.43%	16.15%	17.83%	18.26%	14.97%	1.95%
1985	74.21%	5.92%	8.12%	13.67%	16.94%	14.80%	13.06%	1.70%
1986	65.12%	5.11%	7.71%	11.83%	18.86%	13.40%	13.08%	1.65%
1987	56.26%	4.30%	7.67%	12.20%	21.20%	14.28%	14.43%	1.92%
1988	56.48%	4.35%	8.98%	13.63%	17.96%	16.01%	13.81%	1.97%
1989	58.33%	3.66%	9.40%	13.74%	15.25%	14.71%	12.63%	1.89%
1990	66.95%	5.01%	11.73%	15.14%	13.61%	16.39%	13.30%	2.16%
1991	67.38%	5.58%	13.42%	16.60%	15.30%	15.26%	14.05%	2.35%
1992	65.85%	4.06%	11.80%	12.14%	13.19%	11.02%	11.09%	1.68%
1993	65.77%	3.89%	12.25%	10.39%	14.16%	11.65%	11.26%	1.76%
1994	60.27%	3.84%	13.29%	10.99%	13.50%	11.30%	11.34%	1.82%
1995	58.47%	4.31%	13.12%	11.42%	12.78%	10.56%	11.02%	1.81%
1996	62.73%	4.22%	11.79%	11.87%	11.20%	8.75%	10.05%	1.68%
1997	77.72%	4.64%	10.94%	11.01%	12.05%	7.10%	9.70%	1.54%
1998	102.05%	4.25%	5.66%	10.49%	8.57%	3.99%	7.39%	1.02%
1999	59.50%	1.69%	6.19%	7.29%	8.28%	3.58%	6.05%	0.79%
2000	83.04%	2.03%	7.40%	7.11%	7.89%	4.16%	6.25%	0.84%
2001	77.12%	1.49%	6.52%	6.18%	7.21%	3.78%	5.51%	0.75%
2002	67.69%	1.53%	7.38%	6.65%	8.47%	3.99%	6.27%	0.90%
2003	65.02%	1.80%	9.14%	7.63%	9.85%	4.58%	7.47%	1.17%
2004	61.61%	1.76%	9.97%	8.05%	9.78%	3.99%	7.79%	1.25%
2005	55.92%	1.39%	10.91%	9.16%	8.78%	3.49%	8.14%	1.41%
Ave	66.04%	3.71%	9.62%	11.14%	13.09%	10.00%	10.53%	1.55%

1. The adapted model estimates tax evasion more precisely into the five main taxes. Tax evasion of the adapted model is estimated in each of the five main taxes while Tanzi's approach only estimates tax evasion of total government revenue. The five main tax evasion rates are estimated by applying Lacko's technique to the monetary approach to estimate the tax effectiveness in each tax department.

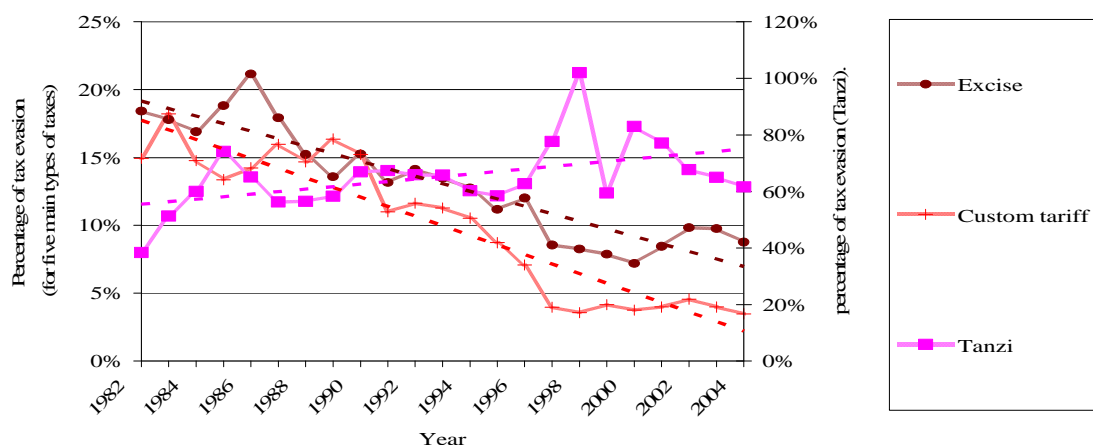
The large difference of tax evasion rate between Tanzi's (66.04%) and the adapted model (10.53%), is 55.51% by average. This is caused by two adaptations of the adapted model; 1) controlling change in the currency at the equilibrium of the demand and supply equations, and 2) the new definition of the velocity of money. The second factor has a larger impact on the difference in estimations than the first factor. The denominator of the velocity of this research's model ($M2$) is much higher than Tanzi's illegal money and as such the velocity of money in this research's is much less than Tanzi's.

2. The estimated results of each method show a difference in tax behaviors during the 1997 Asian economic crisis. The adapted model shows a drop in the tax evasion rate during the crisis while Tanzi's approach shows an increase. The drops are caused by combining the legal effects of tax rate in consideration while the increase is caused by the sharp increase in the velocity of illegal money. Column (9) of the Table 22 (Example to estimate the effectiveness of tax collection of individual income tax from the model) presents an increase in currency from the legal effect of declining tax rate during the crisis period. The legal effect enlarges the drop of illegal currency (column (10)) and results in the drop of tax evasion rate. On the contrary, the sharp increase in the velocity of illegal money is a result of an extreme decline in money during financial crisis⁴. Consequently, this boosts the velocity up to peak. It is difficult to explain why the illegal money had been used more often as legal money in the crisis. Because by the definition of the illegal money, switched from the bank transactions, then the number of the illegal transactions or the velocity of the illegal money should not increase along the

⁴ Before the Asian financial crisis, Thailand faced with a high balance of payment deficit. A governor was designated to change the exchange rate system from a fixed to a managed float exchange rate. This decision shocked the foreign investors in Thailand. They feared that the high balance of payment deficit would make the exchange rate fall bringing loss to the holding of the Thai currency. This fear, when combined with the above speculation, led to a panic outflow of funds causing the exchange rate drop from 25 to 56 Thai baht/US dollar in a short period. This event also caused a sharp drop in legal money (currency) and a sharp rise in its velocity, while the velocity of $M2$ remained normal due to the normalcy of bank transactions.

velocity of legal currency but equate to the number of the original bank transactions or velocity of $M2$ as mention before in 3.2.2 Demand and Supply for currency. On the other hand, the drop in tax evasion rate in the economic crisis can be explained by two main reasons; the decline in the effective tax rate and tax base. The decline in the effective tax rate reduces the incentives to evade tax. The increase in number of unemployed laborers and loss-making firms did not need to pay taxes and therefore did not need to evade them. Another reason is the reducing tax base during the crisis with the development of Thailand's tax capacity. The tax capacity has been developed for supporting the growth of the economy in the future. During the crisis, the intensity of audits increased as tax base decrease while tax capacity – tax auditors and audit technology – remained the same. Thus the drops in tax evasion are more reasonable than the peak.

3. There is a difference in long term tendencies of tax evasion rates between both methods.



4. Figure 5 illustrates the long run downward tendencies of the tax evasion rate from the adapted model. According to Tanzi's approach, tax evasion rate always increases alongside the effective tax rate because the combination between progressive tax rates and economic growth, though audit technologies, are developed over time. Thus methods to reduce tax evasion rate by the monetary approach are 1) to make countries undeveloped and 2) to keep reducing the tax rate when there is economy growth, both of which are undesirable. The long run downward tendencies of tax evasion from the adapted model correspond with the social norms of that in the developed countries where tax administration can control tax evasion well (IMD World competitiveness yearbook team, 2005; Schaffer & Turley, 2000). In addition, the

development of tax capacity can be both positive and negative depending on each tax. Only the corporate income tax evasion rate shows the upward tendency, this will be discussed in the next section.

Although the adapted model estimates more realistic results, a few weaknesses should be noted. First, these equations were created specifically in the long run model to estimate the stable state. The first problem is that some equations do not have the cointegration between dependent and independent variables. Statistically, they may be spurious regressions. However, most variables in this research are selected from the reviewed short-run models. It implies that these variables were tested for a relationship with the independent variables. The second problem is statistically insufficient 23-year observation for various independent equations. However, using the small existing data for estimation is better than waiting for the significant data in the future or not using

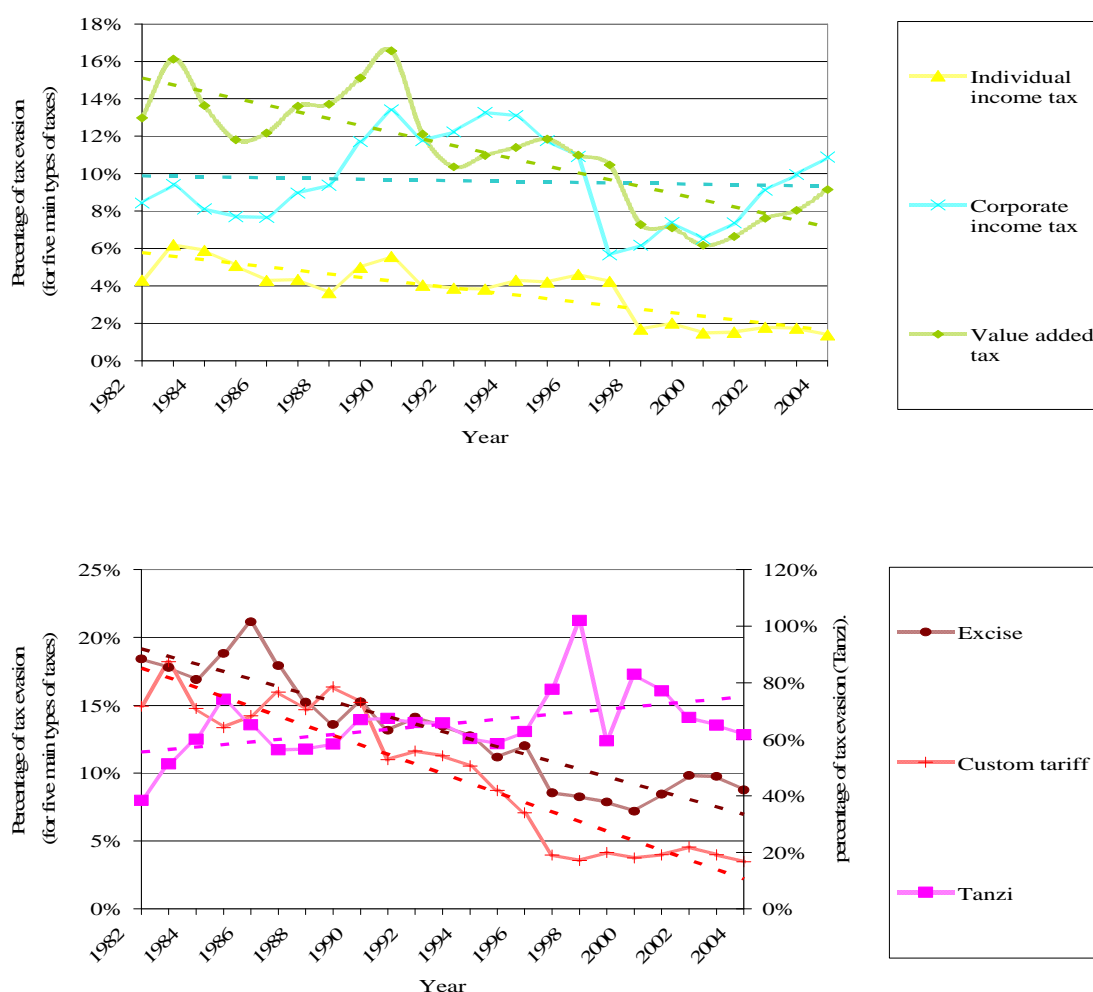


Figure 5 Comparison the tendency of percentage of tax evasion

data at all to make policy now. Finally, the individual income tax evasion is the lowest of the five main taxes. Due to Tanzi's approach, a low effective tax rate causes low tax evasion but the social norm is that individual income tax is an easily evaded tax. For example, it is difficult for Thai tax auditors to monitor or audit the resources of income of every workers, especially freelance and self-employed workers. Many of them receive their incomes in cash and therefore unlike firms, need no more currency to avoid detection of their source of their income. Declaring low income is sufficient to evade tax while firms have to distort their income and simultaneously use currency to hid transactions. This is the reason why the model may not estimate highly accurate tax evasion of individual income tax. In other words, the currency approach may not be appropriate for estimating tax evasion, which is based on a large share of currency income from individual income tax.

3.3.3 IMPROVING THE EFFECTIVENESS OF THAI TAX COLLECTION

The effectiveness of overall Thai tax collection has increased significantly (Figure 6). By considering the red line in the figure, the effectiveness of overall tax collected had only increased slightly in the period before 1997. After 1997, the effectiveness increased sharply during the economic crisis and then decreased near to the level it was previously before the crisis. It can be said that without the crisis, the effectiveness has developed only slightly. However this is a good sign of the development of the Thai tax administration as it is still a positive increase in effectiveness.

According to the study of tax evasion, there are at least three factors influencing the change in the effectiveness of tax collection: 1) Tax rate, 2) crisis and 3) tax capacity. To indicate the change in the tax capacity factor, all three factors must be considered simultaneously. The increasing tax rate causes the downward tendency of the effectiveness, but the graph which considers all three factors illustrates an upward tendency. This implies that the development of tax capacity has a greater influence on the overall effectiveness than the tax rate effects or the evading tax incentive from increasing tax rate. An analysis in detail will clarify the development of each tax.

The next section will explain the change in the tax capacity of Thai five main taxes.

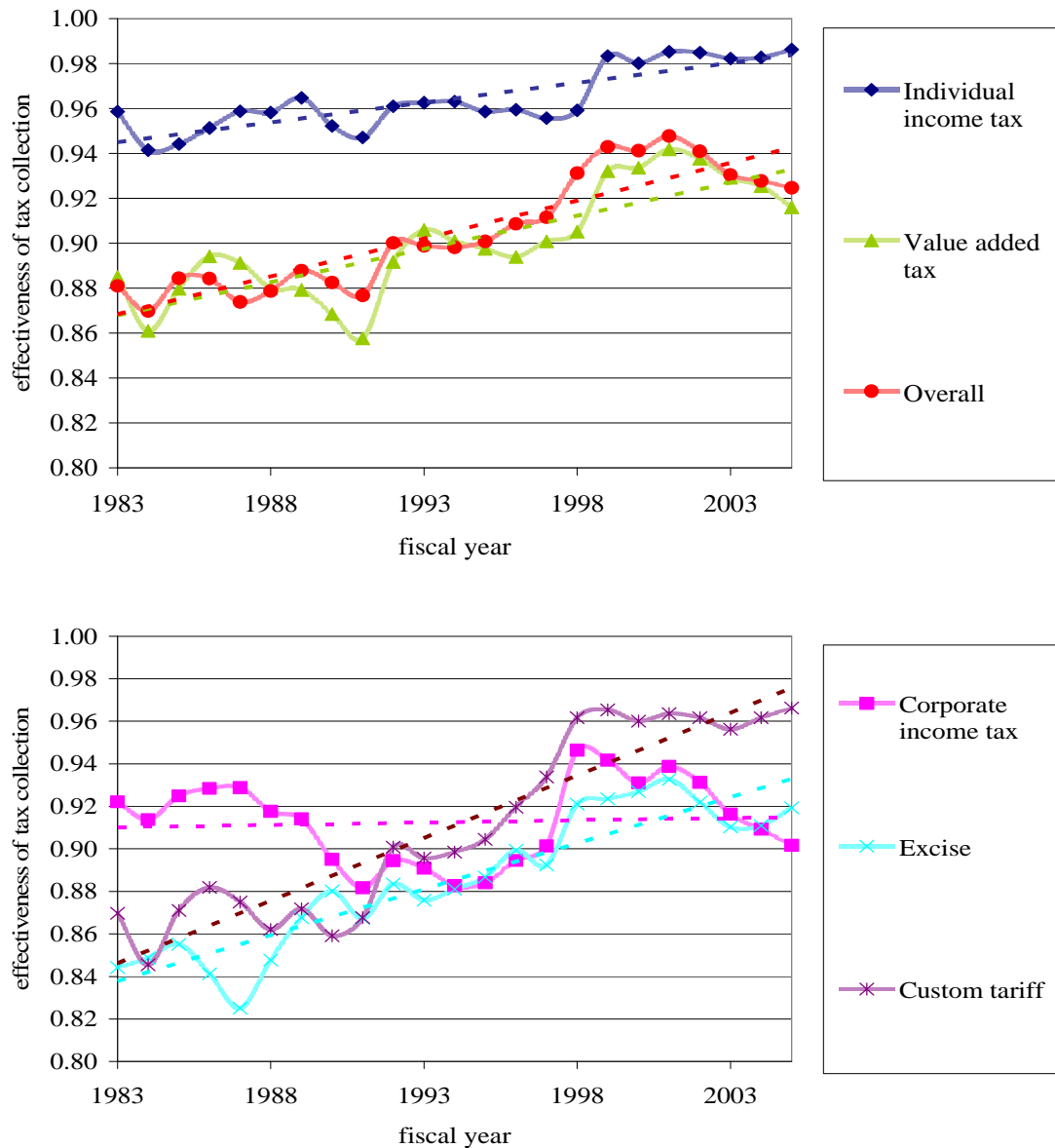


Figure 6 development of the effectiveness of Thai tax collection

1. Individual income tax

The dark blue line presents as the effectiveness of collecting individual income tax. It was almost constant before the crisis, after which it turned to rise sharply. Noticeably, its trend did not decline as with the other taxes. When considering with the negative impact of increasing tax rate on tax evasion, the increase in the effectiveness of collecting individual income tax indicates the increase in tax capacity for collection to overcome the negative factor, both before and after the crisis.

2. Corporate income tax

Only corporate income tax presents an almost constant tendency of effectiveness both before and after the crisis. By considering in detail the effectiveness before and after the crisis, both are downward trends. Thus it is difficult to say whether the tax capacity for corporate income tax has been developed properly. There is a reason that supports the high tax evasion in corporate income tax. Firms can declare fraudulent data in both income and expenditure, especially labor costs. There is the large gap between a minimum wage and a tax threshold. Any firms may declared too much labor costs during this gap and Thai government cannot collect any more tax revenue from both corporate and individual income tax.

3. Value added tax

The slope of the effectiveness of the value added tax line (green line) is very similar to the total effectiveness (red line) because the value added tax is the largest share of the total tax revenue. The major change is the tax reform in 1992 by cancelling the sales and special business taxes and applying value added tax instead. The tax reform impacted the structure of the tax effectiveness as can be seen from the green line which increases significantly since then. It implies that the collecting system of the value added tax helps to promote the effectiveness. It is a self check system between firms, but it is less effective for the last transactions between firms and consumers who cannot use bills to reclaim the value added tax.

4. Excise tax

Tax capacity of the excise department has been developed at the highest rate because the change in effectiveness is due to tax capacity as the effective excise tax rate is constant. Although the effectiveness of both the excise tax and custom tariff increase simultaneously, the effectiveness of custom tariff has been supported by the positive effect of declining custom tariff rate.

5. Custom tariff

The effectiveness of custom tariff collection illustrates the sharpest upward tendency due to the continuous decline in custom tariff rate. Thus, it is difficult to determine how the tax capacity has changed.

The high development of effectiveness for the excise and customs departments may be caused by a good reward incentive system for tax auditors. In comparison, tax auditors in the revenue department do not get any rewards for detecting general errors or share very few rewards with Anti-Money Laundering Office (AMLO) for deliberate tax evasion. When auditors detect the underground income or tax evasion, they have to send the evading tax information to AMLO. Officials of AMLO will then capture and enforce the regulation to tax evaders. The major share of rewards will belong to AMLO's officials and the remaining will be rewarded to the detected tax auditors at around 10% of fines. This is small compared to the 30-55% of summation of fines and exhibits received by excise auditors or to the 25-35% received by customs auditors (Source: Discipline of Ministry of Finance).

3.3.4 PLAN FOR NEXT CHAPTER AND FUTURE STUDY

After the presentation of the above research was given to the upgrade panel, they gave useful advice for developing the research further. The most important advice for the next chapter is a study for the structural break during the economic crisis because there are significant drops of tax evasion during that period. This study may help to improve estimation accuracy and reasonable explanation for the drops in tax evasion. Another interesting advice is that the adapted model should be universal to give it the possibility to be used in any countries' context. For example, applying to the US context, this issue will be presented in section 8, Appendix 3: Tanzi's monetary approach versus the adapted model.

The tax effectiveness model can be used for promoting the effectiveness in various directions. The first example is using the model for the budget allocation of tax departments. By studying the relationship between the effectiveness and budget allocation of three tax departments, this can help the Thai government plans to invest in each department for collecting optimum taxes. A necessary condition to achieve the optimum points is to devote tax collection cost to the point where the marginal cost equals the marginal tax revenue in each department. Furthermore, one should consider the proportion of technology cost and tax official salaries as reward incentives to drive the effectiveness of each factor to the optimum cost. This scheme can either decrease collection costs or increase tax revenue collected.

The second example, the relationship between the effectiveness and tax rate, can be used as a considering condition in tax reform for maximizing the effectiveness and promoting the vertical and horizontal equities by adjusting for the optimum tax rate.

Figure 7 presents the direction tax rates reform should take in order to promote tax effectiveness and the horizontal and vertical equities, assuming total tax revenue remains constant. Thai government can maintain the tax revenue by reducing the individual income tax rate and increasing the corporate income and value added taxes. The excise and custom tariff taxes are categorized as political taxes, which should only be adjusted for specific political reasons such as to govern consumer behavior. In order to manipulate the amount of tax revenue collected, it would be better to change the tax rates of the first three taxes as opposed to political taxes. If the tax rates are changed as recommended, the average tax effectiveness will increase from 0.92 to 0.94. Individual income tax is a precise progressive tax while the flat rate of value added and corporate income taxes are comparatively progressive taxes, so the tax reform can promote vertical equity with the higher progressive tax rate. Lastly, the higher tax effectiveness promotes the horizontal equity by reducing tax evasion. This model should be considered for next tax reform when the Thai government desires to change the expected tax revenue. A crucial issue for future study is the reward incentives for controlling corruption. Due to the low tax revenue of the Thai government, the ideas

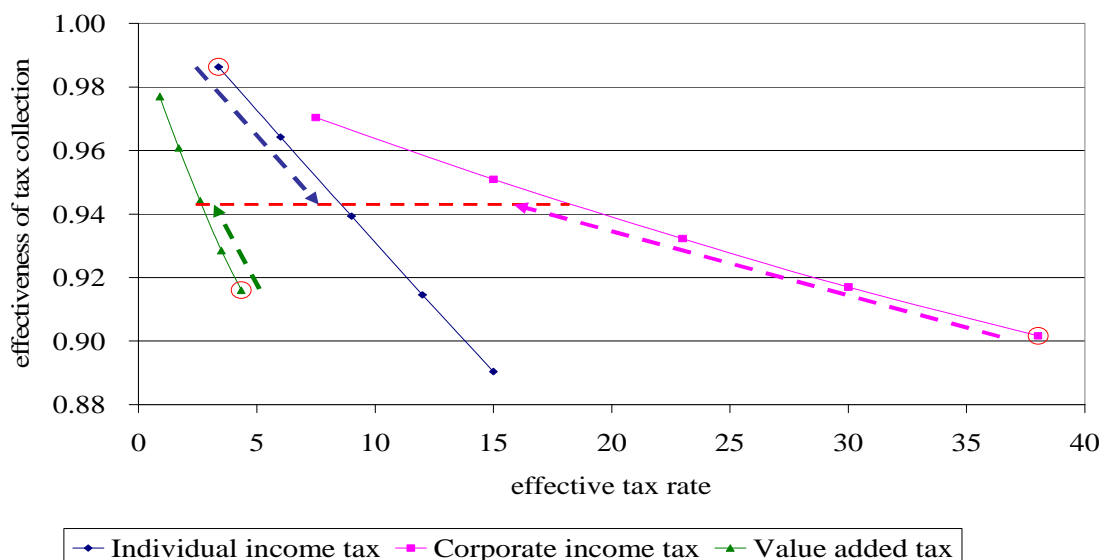


Figure 7 Planning diagram for the tax reform

mentioned above can be used to promote the tax effectiveness to increase tax revenue both in the terms of tax administration (budget allocation) and tax reform for reducing tax evasion. However this research does not attempt to form a method to deal with the corruption problem in the Thai tax system. Corruption is a very influential factor of the low tax revenue and a ranking done by IMD University placed Thailand at 44 out of 60 countries, with the least corrupted country at number 1. For that ranking, if the number 10 means no corruption exist in the economy, Thailand scored at 2.69 (IMD World competitiveness yearbook team, 2005). The reward incentive is a prevalent method to deal with tax corruption. If it is possible to set up the right reward incentive by using game theory, this can encourage tax auditors to refuse bribes or corruption.

3.4 CONCLUSION

The purpose of this chapter is to estimate the effectiveness of tax collection. From the review of literature on the topic of tax evasion, the effectiveness model is established by focusing on Tanzi's monetary approach and the TCMP method can be applied to measure the individual tax auditor's performance indicators. These indicators help to promote their incentive to audit more faults both in reported income and tax evasion by linking the performance indicators with salary promotion at the end of the fiscal year.

Coming back to the tax effectiveness model, The effectiveness model consists of three set of equations: 1) effectiveness equation, 2) currency demand and supply equations, and 3) legal effect equations. The effectiveness equation is used to convert the estimated tax evasion into the tax effectiveness. The currency demand and supply equations are adapted from Tanzi's approach with four following issues: 1) direct estimation of currency variable instead of the ratio of currency to $M2$, 2) adding up currency supply equation including $M1$ and deposit rate variables for more accurate estimation, 3) tax rate is distributed into five main taxes for estimating the effectiveness of each tax, and 4) the model estimates the long run relationship to form an estimation of tax evasion at the stable state when there is a change in the tax rate. The demand and supply equations are used to estimate the total tax rate effects on currency at the equilibrium of demand and supply. The legal effect equations, macro economic model, are used to estimate the legal tax rate effects and indicate the illegal effects from the total effects for estimating the underground economy and tax evasion. Basically, tax rate correlates positively with currency by Tanzi's assumption but the legal effects present a negative relationship.

This is because tax rate is a negative multiplier in the macro economy and with currency when it is a medium of transactions as this relates to the size of economy.

Firstly, the results are compared with the original method of Tanzi. There are many differences between the estimated tax evasions from Tanzi's approach and the adapted model, but four interesting results should be considered: 1) Tanzi's results present a higher magnitude of tax evasion because of the different definition of the velocity of money, 2) the adapted model estimates the drop in each tax evasion in the economic crisis because of reducing the effective tax rate and the legal effects while Tanzi's presents the peak of tax evasion because of the velocity of money, and 3) long term tendency of tax evasion should be both upward or downward while the long term tendency of Tanzi's is always upward because of increasing effective tax rate from combination of economic growth and the progressive tax rate. The last two findings are particularly important; the drops of tax evasion in the recession is against the general thinking that low income countries face a high tax evasion problem and the model can explain the decrease in tax evasion when the effective tax rate grows. However, this research has its limitations. Firstly, there are only 23 or less observations in each model which is quite low by statistics. Secondly, it specifically uses long run models which may face spurious regression problem. Lastly, the tax evasion rate of individual income may not be as low estimated because a high proportion of individual income is paid by currency and as such taxpayers do not need any more currency to avoid detection of source of income to evade tax.

The last section discussed about the development in tax capacity and tax effectiveness. Factors of change in the tax effectiveness are set up as tax rate, the economic crisis and the tax capacity. It can be concluded that total tax capacity has increased because it overcomes the negative effect from the increase in tax rate. The tax capacity of individual income tax, value added tax and excise tax has increased and overcomes the negative impact of tax rate. Excise tax shows the best development in tax capacity. Although the effectiveness of custom tariff collection increases with the sharpest rise, it cannot be used to define the direction of change in tax capacity due to the simultaneous decline in custom tariff tax rates. Only corporate income tax capacity presents a downward tendency for both before and after the crisis. This may be caused by the reward incentive system in the revenue department.

4 TEST FOR STRUCTURAL BREAK IN TAX EVADERS' BEHAVIOR DURING THE ECONOMIC CRISIS

4.1 INTRODUCTION

This additional chapter was advised by the upgrade panel for a more accurate estimation of Thai tax evasion during the Southeast Asia financial crisis of 1997. Referring to chapter 3, the high drops in tax evasion rates may have been caused by the changes in tax evaders' behaviors (Figure 8).

The purpose of this chapter is to test for structural breaks of tax evasion behaviors during the crisis. The three equations which will be tested for structural breaks are the currency demand and currency supply equations and the legal effect equation. This is because structural breaks can occur in any process of the tax evasion estimation especially in the legal effects (relationship of the significant transactions and tax rate). By considering the Table 22 and Figure 8, the legal effect in column 9 show a precise break in 1999; this is seen as a high drop of 2.24% in the significant transactions as compared to the maximum drop from total effect (column 5) of 0.23% in 1999. The methodology used to test the break in this chapter is a dummy variable test method with panel data. The results will be described in both testing results of the structural break and the estimated tax evasion results from the panel model.

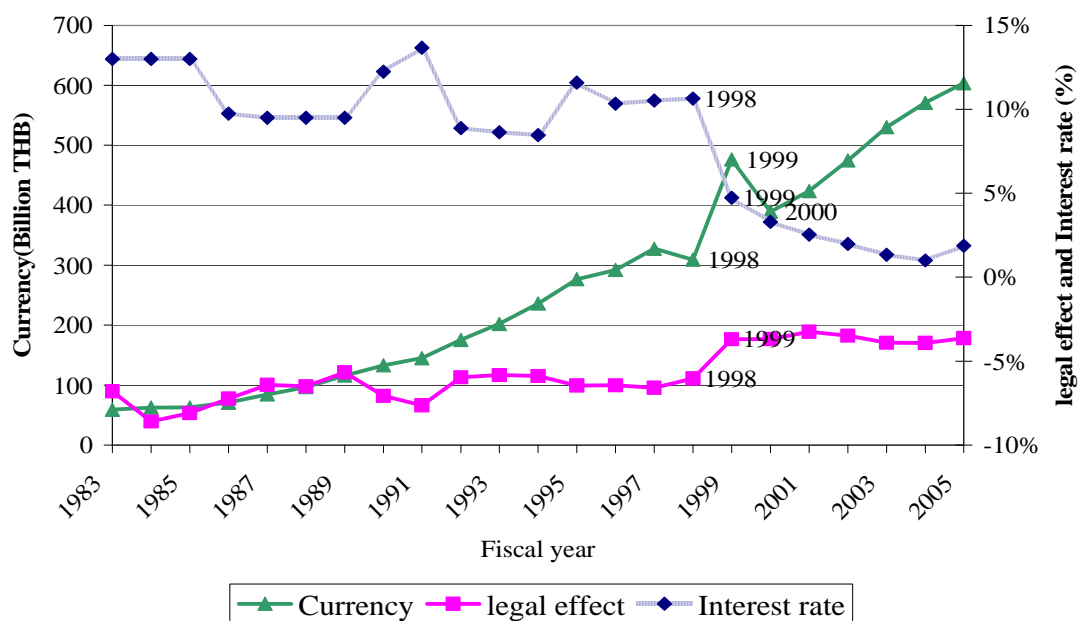


Figure 8 Structural breaks of each variable during the crisis

4.2 MODEL

The model in this chapter has been adapted from chapter 3 to test for the structural breaks. Figure 8 presents various forms of breaks such as completely changed behaviors of legal effect and interest rate after the crisis, and a shocked period of currency outflow may only last of two years (1998-1999) after which behaviors returned to normal. However, the model is not considered only an individual break of dependent or independent variable but considered entire variables in the system. So the structural breaks after considering all break variables are unknown date and unknown form. Various forms of structural break will be trial for the best explanation of the change after crisis.

Some examples of breaks are, 1) a shocked period which, or. One or two-year observations are too low to confirm the structural break statistically. To make the model more confidential, the model should be estimated in panel data as a group of countries in Southeast Asia and South Korea because these economies were highly affected by the crisis. Summation of those countries' observations makes the panel model more statistically significant. Chow test will be used in this research for test structural breaks as constant terms or changes in slopes. The constant term break is characterized by behavior changes at a fixed value in a period of break. The slope break is characterized by the changing relationship between independent and dependent variables in a period of break.

4.3 RESULTS AND DISCUSSION

Results of this chapter will be presented in two parts; tested structural break results and estimated tax evasion results of the panel model. The tested results present a significant break in two equations: the currency supply equation and the legal effect equation.

4.3.1 RESULTS OF THE STRUCTURAL BREAK TEST

This section presents the tested results of the currency demand and supply equations and the legal effect equation. The results present that the crisis dummy of the supply equation is the best explanation for the structural break.

When the demand equation is estimated in isolation using the ordinary least squares method (OLS), the tested results present a structural break during 1997-1998. However,

after re-computation with the supply equation containing the 1997 crisis dummy (D_{97} is 0 from 1997 otherwise 1 before 1997) in the system using the two stage least squares method (TSLS), the coefficient of the break dummy becomes insignificant. This implies that there was no change in the currency demand behavior in the crisis but that the structural break in currency supply from financial institutes affects indirectly on the population's decisions. Tested results of the demand side in isolation show a structural break in constant term during 1997-1998 and no change in the slope of the relationship between tax rate and currency. The coefficient of the 1997-98 dummy is tested by Wald method which produced an $F\text{-statistic}_{(1,136)}$ of 4.539. This is evidence against the null hypothesis of the coefficient = 0 at $p\text{-value} = 0.0349$. Wald test results also reported no significant difference between the slopes of the tax rate variables during 1997-98 and before or after 1997-98. This is shown in the $F\text{-statistic}_{(1,135)}$ of 2.103. This evidence accepts the null hypothesis that both coefficient are equal at $p\text{-value} = 0.1493$. However, by considering the re-computation in the system of currency demand and supply, the demand break property is insignificant. By changing the method used from OLS to TSLS and including instrument variables from the supply side, the resultant $F\text{-statistic}_{(1,120)}$ is 0.3974. This evidence accepts the null hypothesis that the coefficient = 0 at $p\text{-value} = 5.297$; there is no structural break in the demand equation.

Final estimation output of the currency demand and supply equations does not contain any new dummy break variables except for the previous crisis dummy in the supply side. Disposal income variable (DI) is used in this model to compensate the legal effect. Time variable (T) is used to replace the technology variable. The dummy variables for seven countries are presented as Cambodia (CAM), Indonesia (IND), Malaysia (MAL), Philippines (PHI), Singapore (SIN), South Korea (SKR) and Thailand (THA) and the constant term presents a base case for Vietnam. By considering the supply side, the deposit rate (R) depends on the amount of deposits (D) and the loan rate (RL).

The last equation, tested for a structural break, is the legal effect equation especially for the relationship between currency and the significant transactions. Due to the panel equations, the disposal income variable is used to represent the legal effect and the macroeconomic model cannot be created in a complete system. The structural break test is then applied to solely in the Thai context from chapter 3. The results present a structural break of the relationship during 1997-1998. The coefficient test by Wald method presents the $F\text{-statistic}_{(1,21)}$ of 3.945. This is evidence against the null hypothesis

that the coefficient = 0 at p-value = 0.0602. The estimation output of the legal effect equation presents as follows:

Table 9 Currency Demand equation

Dependent Variable: $\ln\left(\frac{C}{P}\right)$

Method: Two-Stage Least Squares

Included observations: 133

Instrument list: $\ln(RL)$ $\ln(1+TR)$ $\ln\left(\frac{(GDP-TX)}{P}\right)$ *CAM IND MAL PHI SIN SKR THA T*

<i>D97</i>				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
<i>C</i> (Vietnam is base case)	-3.642383	0.286423	-12.71679	0.0000
$\ln(1+TR)$	0.636707	0.101815	6.253543	0.0000
$\ln\left(\frac{(GDP-TX)}{P}\right)$	0.807853	0.027448	29.43257	0.0000
$\ln(R)$	-0.179742	0.042152	-4.264167	0.0000
<i>T</i>	-0.010484	0.003116	-3.364870	0.0010
<i>CAM</i>	-0.936216	0.103772	-9.021878	0.0000
<i>IND</i>	-0.161198	0.104010	-1.549831	0.1238
<i>MAL</i>	-0.151412	0.074220	-2.040047	0.0435
<i>PHI</i>	-0.254355	0.074330	-3.421951	0.0008
<i>SIN</i>	-0.305109	0.097079	-3.142904	0.0021
<i>SKR</i>	-0.444896	0.099371	-4.477128	0.0000
<i>THA</i>	-0.092486	0.075388	-1.226797	0.2223
Adjusted R-squared	0.989417 Durbin-Watson stat			0.856696

Table 10 Currency supply equation

Dependent Variable: $\ln(R)$

Method: Two-Stage Least Squares

Included observations: 102

Instrument list: $\ln(RL)$ $\ln(1+TR)$ $\ln\left(\frac{(GDP-TX)}{P}\right)$ *CAM IND PHI SIN SKR THA T D97*

Variable	Coefficient	Std. Error	t-Statistic	Prob.
<i>C</i> (Vietnam is base case)	-2.033361	0.483623	-4.204438	0.0001
$\ln\left(\frac{D}{P}\right)$	-0.204283	0.077103	-2.649483	0.0095
$\ln(RL)$	1.466812	0.172337	8.511305	0.0000
<i>CAM</i>	-2.040239	0.258971	-7.878244	0.0000
<i>IND</i>	0.534025	0.277443	1.924806	0.0573
<i>PHI</i>	0.321414	0.227172	1.414850	0.1605
<i>SIN</i>	0.129100	0.240347	0.537139	0.5925
<i>SKR</i>	0.935501	0.310174	3.016050	0.0033
<i>THA</i>	0.516539	0.272834	1.893235	0.0615
<i>D97</i>	-0.292937	0.101024	-2.899671	0.0047
Adjusted R-squared	0.857024 Durbin-Watson stat			0.419011

The structural break of legal effect equation is specifically tested for the break of the relationship between currency (C) and the significant transactions in the Thai context (ST). $D78$ is the crisis dummy which equates to 1 for the time period 1997 to 1998 and equates to 0 otherwise.

$$\ln\left(\frac{C}{P}\right) = -2.596 + 0.9978\ln\left(\frac{ST}{P}\right) - 0.1011D78$$

(-9.518)*** (38.15)*** (-1.986)*

Adjusted R-squared = 0.9847

Durbin-Watson stat = 2.779

4.3.2 ESTIMATED TAX EVASION OF EACH COUNTRY

Tax evasion rates of the countries in Southeast Asia and South Korea are presented in Figure 9. Most of the countries' resultant tendencies are downward except for Indonesia's as Indonesia is in a recovering period after the 1997 crisis. The tax evasion rates of Cambodia and Vietnam have fallen more sharply than other countries because the growth rates of the illegal money of both countries are much less than the growth rate of broad money. It implies that the ratio of the underground economy to recorded economy has declined comparatively.

By comparison with previous literature, the ranking placement of each country from the surveying results of International institute for management development (IMD) world competitiveness (2005) and hidden economy around the world by electricity consumption method (Schneider, 2005), are almost similar to the estimated ranking results of the panel model with the exception of the placement of Thailand. (Table 11). The questionnaires answered by private managers used by the IMD model present that Thailand is the second most difficult country to evade tax in among the considered countries whereas Schneider estimated that Thailand has the highest ratio of underground economy to GDP and thus has high tax evasion. Due to the difference in definition of the underground economy by Schneider and this research, and that the direct method by IMD is usually more reliable than the indirect method of the electricity consumption, thus the ranking by IMD is more appropriate for comparison with the estimated results of the panel model. The panel model's results are quite similar to the ranking estimated by IMD. The ranking estimated by IMD with increasing ease to evade tax are Singapore, Thailand, South Korea, Malaysia, Indonesia, and Philippines.

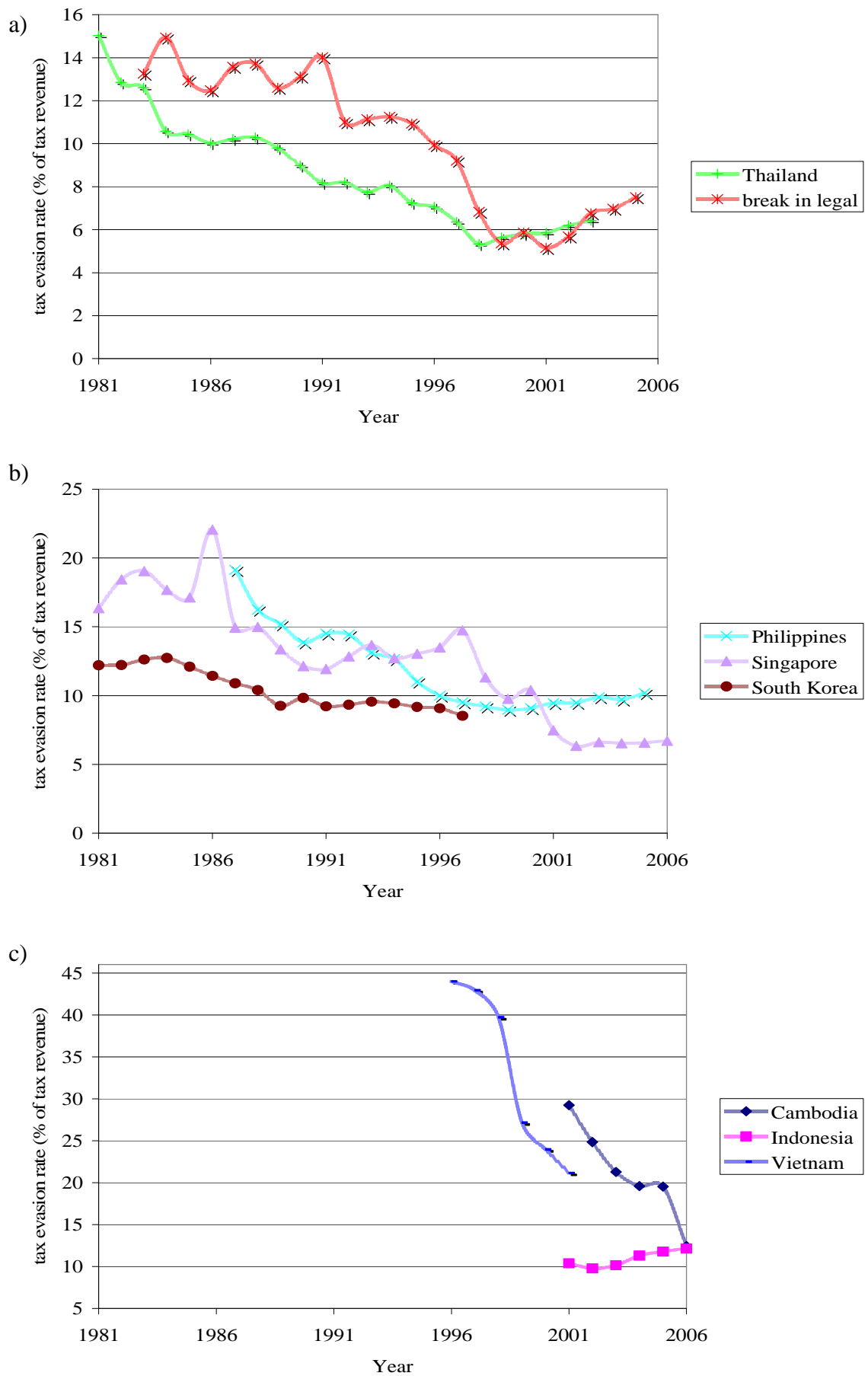


Figure 9 Comparison tax evasion rate

Although the estimated results of this research are slightly imprecise due to missing data from 2005, the estimated ranking of the Philippines is obviously different between the two methods and the ranking of Thailand has been better than Singapore's till 2002. These may be because of tax corruption, another kind of tax evasion, which is not included in the estimation of this research. This can be noticeable from the high rate of corruption by the IMD reports. It could be said that this panel model is reasonably acceptable.

Table 11 comparison of tax evasion and underground economy rates

Ranking	Schneider (% of $\frac{UE}{GDP}$)	Ranking	IMD (Score)	Ranking	Panel data (% of $\frac{UE}{GDP}$)	Ranking	Panel data (% of $\frac{UE}{GDP}$)
	1990-1993		2005		1990-1993		2005
1	Singapore (13)	7	Singapore (6.24)	1	Thailand (8.3)	1	Singapore (6.6)
2	Korea (38)	30	Thailand (4.45)	2	Korea (9.5)	2	Thailand (expected)
3	Malaysia (39)	31	Korea (4.43)	3	Singapore (12.7)	3	Philippines (10.2)
4	Philippines (50)	32	Malaysia (4.40)	4	Philippines (14.0)	4	Indonesia (11.8)
5	Thailand (71)	48	Indonesia (3.37)			5	Cambodia (19.5)
		52	Philippines (2.73)				

By comparison of Thai results between the panel model (Green line) and the adapted model with the structural break in the relationship of currency and significant transactions from chapter 3 (Red line) in figure 11, they are quite similar in the range of the tax evasion rate, the downward tendencies, and the drops and recovering during the crisis. The tax evasion rate of the panel model is dropped at a lower rate than the adapted model at the beginning of the crisis because of the incomplete legal effect equation. If it was possible to consider a complete legal effect for the panel model, the tax evasion rate will increase by the multiplier of the tax rate in the macroeconomic model.

The last issue is the consideration of the structural break in tax evasion rate during the crisis by comparison of the legal effect between with and without the structural break. The produced results are almost similar. This implies that the drops of the tax evasion

rate in the crisis are caused by the high drops in effective tax rates, not by a change in behaviors.

4.4 CONCLUSION

The purpose of this chapter is to test the structural break in the effectiveness model. Due to the results in chapter 3, there are obvious drops of tax evasion rate during the Southeast Asia financial crisis, 1997. Statistically, this panel model confirms the structural break of the legal effect equation by the highly significant coefficient of break dummy variable.

By comparing tax evasion rates of each Southeast Asia country with the ranking of IMD world competitiveness in 2005, the ranks are almost similar in both the results of the IMD model and this research. This implies that the panel structural break model is reasonably acceptable. The estimated results show downward tendencies of tax evasion rates for most countries except Indonesia. The structural break model estimates a drop and a recovering of Thai tax evasion rate as with the results from chapter 3, but the drop is not as large a magnitude as that of chapter 3. The most important result of the structural break test is that the tax evasion drop in the crisis is caused by the high drop in the effective tax rate, the break does not concern a change in behaviors.

5 CONCLUSION

Low tax revenue is an acute problem for the Thai Government, one which causes a lack of funds for much needed economic and social development such as improving social welfare and the education system. The cause of the low tax revenue is ineffective tax administration. Thus the purpose of this research is to measure the effectiveness of tax collection in Thailand.

This research began with the review of the circumstances of the Thai tax system and tax evasion approaches, the tax effectiveness model in this research is established by focusing on Tanzi's monetary approach and the TCMP method can be applied to measure the individual tax auditor's performance indicators for helping to promote their incentive to audit more tax evasion.

The popular Tanzi's monetary approach is used to estimate the level of tax evasion and has resulted in the hypothesis that tax evasion generally increases alongside the growth of the economy. However, Tanzi's approach overlooks two aspects which reduce the accuracy of the findings: velocity of money and the legal effect of the tax rate. Thus, in this research, four adaptations, [1) direct estimation of currency variable instead of the ratio of currency to $M2$, 2) adding up currency supply equation including $M1$ and deposit rate variables for more accurate estimation, 3) tax rate is distributed into five main taxes for estimating the effectiveness of each tax, and 4) the model estimates the long run relationship to form an estimation of tax evasion at the stable state when there is a change in the tax rate], were made in order to achieve more accurate estimation. Furthermore, the tax effectiveness model also includes the tax effectiveness equation and the legal tax rate effect equations not only the adapted monetary approach.

Figures suggest firstly that as the economy has grown, tax evasion has reduced, but that secondly, the least tax evasion occurred during the economic crisis of 1997. The former finding corresponds to the research by IMD surveys (2005) which showed that highly developed countries have low tax evasion. The latter finding was tested for structural break and the results support the view that there is no change in behavior during the crisis but that the high drop of tax evasion is caused by both the legal and illegal effects of tax rate.

Furthermore, the tax capacities are also roughly indicated by removing the tax rate effect and economic crisis factor off the tax effectiveness. It can be said that total tax capacity has increased because it overcomes the negative effect from the increase in tax rate. The tax capacities of individual income tax, value added tax and excise tax has increased significantly while the capacities of cooperate income tax and custom tariff cannot be firmly indicated.

By comparing estimated tax evasion rates of each Southeast Asia country from structural break panel model with the ranking of IMD world competitiveness in 2005, the ranks are almost similar in both the results. This implies that the panel structural break model is reasonably acceptable. The estimated results also show downward tendencies of tax evasion rates for most countries and the most important result of the structural break test is that the tax evasion drop in the crisis is caused by the high drop in the effective tax rate, the break does not concern a change in behaviors.

From the findings in this research, the applied TCMP method can be directly use to encourage the individual tax auditors, but the results of Thai tax capacities must be considered in the next step of government expenditure allocation for optimal budget to each tax departments. Moreover, the characters of tax evasion collusion should be studied to set up the new detecting reward incentive. If it possibly reaches to these points, the Thai tax revenue must be increase to satisfactory level.

6 APPENDIX 1: ESTIMATION OUTPUT OF THE MODELS

This research contains three models which are used in the Thai context; 1) Tanzi's monetary approach, 2) the adapted model and 3) structural break panel model. All the variables in this research are denoted as follows:

List of variables

- c = Constant term in structural break demand equation presents as Vietnam
- C = Currency outside depository corporation
- \hat{C} = Estimated currency at current tax rate
- $\hat{\hat{C}}$ = Estimated currency at zero tax rate
- D = Deposit
- $D97$ = Dummy variable for financial crisis since 1997
- CAM = Dummy variable for Cambodia
- IND = Dummy variable for Indonesia
- MAL = Dummy variable for Malaysia
- PHI = Dummy variable for Philippine
- SIN = Dummy variable for Singapore
- SKR = Dummy variable for South Korea
- THA = Dummy variable for Thailand
- DI = Disposal income
- Ef = Effectiveness of tax collection
- Ex = Exchange rate
- G = Government expenditure
- GDP = Gross domestic product
- GWP = Gross world product
- I = Investment
- L = Loan
- M = Imports
- $M1$ = Narrow money
- $M2$ = Broad money
- NI = National income
- P = Price index
- PC = Private consumption

- R = Deposit rate
- RD = Discount rate from central bank
- RL = Loan rate
- RW = World interest rate (LIBOR)
- SD = Significant transactions
- ST = Significant transactions
- T = Effective tax rate
- T_{78} = Effective tax rate during 1997-1998
- T_{n78} = effective tax rate except 1997-1998
- TB = Tax base
- TE = Tax evasion
- Tx = Tax revenue
- UE = Underground economy
- v = Velocity of money
- WS = Wages and salaries
- X = Exports
- Y = Income per capita
- $?_{ii}$ = Individual income tax
- $?_{ci}$ = Corporate income tax
- $?_v$ = Value added tax
- $?_e$ = Excise tax
- $?_c$ = Custom tariff

6.1 TANZI'S MONETARY APPROACH

Tanzi's monetary approach is applied in the Thai context for testing. This testing proves Tanzi's assumption of each relationship, but the independent variables cannot adequately explain the change in the dependent variable. The estimation output of the equation presents the adjusted R-Squared at only 0.6841 and two insignificant coefficients; tax rate and the ratio of wages and salaries to National income. The adapted model presents more meaningful equations in the following tables.

Table 12 Estimation output of Tanzi's monetary approach

Dependent Variable: $\text{LN}\left(\frac{C}{M2}\right)$

Method: Least Squares

Date: 08/31/08 Time: 01:12

Sample(adjusted): 1982 2005

Included observations: 24 after adjusting endpoints

$$\text{LN}\left(\frac{C}{M2}\right) = c(1) + c(2) * \text{LN}(1+T) + c(3) * \text{LN}\left(\frac{WS}{NI}\right) + c(4) * \text{LN}(R) + c(5) * \text{LN}(Y)$$

	Coefficient	Std. Error	t-Statistic	Prob.
$c(1)$	7.748104	1.306733	5.929369	0.0000
$c(2)$	0.278359	0.572549	0.486175	0.6324
$c(3)$	0.234356	0.548008	0.427650	0.6737
$c(4)$	-0.089179	0.039737	-2.244229	0.0369
$c(5)$	-0.670635	0.253000	-2.650731	0.0158
R-squared	0.739026	Mean dependent var		2.118323
Adjusted R-squared	0.684084	S.D. dependent var		0.183749
S.E. of regression	0.103279	Akaike info criterion		-1.519722
Sum squared resid	0.202663	Schwarz criterion		-1.274294
Log likelihood	23.23666	Durbin-Watson stat		1.545534

6.2 THE ADAPTED MODEL

The adapted model in chapter 3 is presented in 3 categories of equations; 1) the effectiveness equation, 2) the demand and supply for currency equations, and 3) the legal effect equations. The effectiveness equation is an identity. The estimation outputs of last two groups will be presented as follows.

1. Demand and supply for currency equations

The following shows the equilibrium of demand and supply for currency equations. The demand for currency is based on from people's behaviors on holding currency based on Tanzi's monetary approach while the supply for currency is based on financial factors originating from financial institutions.

Table 13 estimation output of demand and supply for currency equations

Dependent Variable: $\text{LN}\left(\frac{C}{P}\right)$

Method: Generalized Method of Moments

Sample(adjusted): 1983 2005

Included observations: 23 after adjusting endpoints

Kernel: Bartlett, Bandwidth: Fixed (2), No prewhitening

Simultaneous weighting matrix & coefficient iteration

Instrument list: $\text{LN}\left(\frac{M1}{P}\right)$ $\text{LN}(1+T_{ii})$ $\text{LN}(1+T_{ci})$ $\text{LN}(1+T_v)$ $\text{LN}(1+T_e)$ $\text{LN}(1+T_c)$
 $\text{LN}\left(\frac{WS}{P}\right)$ $\text{LN}(Y)$ $\text{LN}\left(\frac{GDP}{P}\right)$

Demand for currency

Date: 09/02/08 Time: 11:22

Convergence achieved after: 10 weight matrices, 11 total coef iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$\text{LN}(1+T_{ii})$	-0.718806	0.260530	-2.759012	0.0154
$\text{LN}(1+T_{ci})$	0.323787	0.275229	1.176424	0.2590
$\text{LN}(1+T_v)$	0.607378	0.233652	2.599499	0.0210
$\text{LN}(1+T_e)$	0.290831	0.199321	1.459111	0.1666
$\text{LN}(1+T_c)$	0.376057	0.152494	2.466037	0.0272
$\text{LN}\left(\frac{WS}{P}\right)$	1.885404	0.532298	3.542005	0.0033
$\text{LN}(R)$	-0.186205	0.045531	-4.089598	0.0011
$\text{LN}(Y)$	-2.645932	0.874112	-3.026995	0.0091
$\text{LN}\left(\frac{GDP}{P}\right)$	1.512243	0.582179	2.597558	0.0211
R-squared	0.988722	Mean dependent var	7.856715	
Adjusted R-squared	0.982277	S.D. dependent var	0.527494	
S.E. of regression	0.070225	Sum squared resid	0.069041	
Durbin-Watson stat	2.185473	J-statistic	0.012565	

Supply for currency

Date: 09/02/08 Time: 11:24

Convergence achieved after: 23 weight matrices, 24 total coef iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.963934	0.160675	-5.999293	0.0000
$\text{LN}\left(\frac{M1}{P}\right)$	1.066588	0.017792	59.94799	0.0000
$\text{LN}(R)$	0.055202	0.011559	4.775700	0.0001
R-squared	0.986187	Mean dependent var	7.856715	
Adjusted R-squared	0.984806	S.D. dependent var	0.527494	
S.E. of regression	0.065021	Sum squared resid	0.084555	
Durbin-Watson stat	0.541919	J-statistic	0.235430	

2. Legal effect equations

The legal effect equations consist of 10 equations, of which three equations are identities. Nine equations are simple macroeconomic models and the last is an identity of significant transactions (*ST*). The 10 equations comprise of 24 variables – 10 endogenous and 14 exogenous variables.

Table 14 Estimation output of private consumption equation (*PC*)

Dependent Variable: $\text{LN}(PC)$

Method: Generalized Method of Moments

Date: 09/25/08 Time: 22:34

Sample(adjusted): 1982 2005

Included observations: 24 after adjusting endpoints

Kernel: Bartlett, Bandwidth: Fixed (2), No prewhitening

Simultaneous weighting matrix & coefficient iteration

Convergence achieved after: 1 weight matrix, 2 total coef iterations

Instrument list: Tx_{ii} Tx_{ci} Tx_v Tx_e Tx_c $D97$ GWP $\text{LN}(X_{-1})$ $\text{LN}\left(\frac{RD}{RW}\right)$

$\text{LN}(Ex_{-1})$ SD G $\text{LN}(D)$ $\text{LN}(RD)$ $\text{LN}(L)$ $\text{LN}(MI)$ P					
Variable	Coefficient	Std. Error	t-Statistic	Prob.	
$\text{LN}(GDP-TXII-TXCI-TXV-TXE-TXC)$	0.972774	0.000340	2860.325	0.0000	
R-squared	0.996829	Mean dependent var		14.28056	
Adjusted R-squared	0.996829	S.D. dependent var		0.656993	
S.E. of regression	0.036998	Sum squared resid		0.031484	
Durbin-Watson stat	0.324022	J-statistic		0.349580	

Table 15 Estimation output of investment equation (*I*)

Dependent Variable: $\text{LN}(I)$

Method: Generalized Method of Moments

Date: 09/25/08 Time: 22:36

Sample(adjusted): 1982 2005

Included observations: 24 after adjusting endpoints

Kernel: Bartlett, Bandwidth: Fixed (2), No prewhitening

Simultaneous weighting matrix & coefficient iteration

Convergence achieved after: 116 weight matrices, 117 total coef iterations

Instrument list: Tx_{ii} Tx_{ci} Tx_v Tx_e Tx_c $D97$ GWP $\text{LN}(X_{-1})$ $\text{LN}\left(\frac{RD}{RW}\right)$

$\text{LN}(Ex_{-1})$ SD G $\text{LN}(D)$ $\text{LN}(RD)$ $\text{LN}(L)$ $\text{LN}(MI)$ P					
Variable	Coefficient	Std. Error	t-Statistic	Prob.	
$\text{LN}(GDP)$	1.352010	0.009022	149.8566	0.0000	
$\text{LN}(RRL)$	-1.300652	0.027182	-47.84942	0.0000	
$D97$	-0.826479	0.014228	-58.08623	0.0000	
R-squared	0.975623	Mean dependent var		13.65093	
Adjusted R-squared	0.973301	S.D. dependent var		0.717875	
S.E. of regression	0.117299	Sum squared resid		0.288938	
Durbin-Watson stat	0.543493	J-statistic		0.315681	

Table 16 Estimation output of export equation (*X*)

Dependent Variable: $\text{LN}(X)$

Method: Generalized Method of Moments

Date: 09/25/08 Time: 22:37

Sample(adjusted): 1982 2005

Included observations: 24 after adjusting endpoints

Kernel: Bartlett, Bandwidth: Fixed (2), No prewhitening

Simultaneous weighting matrix & coefficient iteration

Convergence achieved after: 26 weight matrices, 27 total coef iterations

Instrument list: $Tx_{ii} Tx_{ci} Tx_v Tx_e Tx_c D97 GWP LN(X_{-1}) LN\left(\frac{RD}{RW}\right)$

$LN(Ex_{-1}) SD G LN(D) LN(RD) LN(L) LN(MI) P$

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$LN(GWP \times Ex)$	0.017586	0.002166	8.119480	0.0000
$LN(X_{-1})$	0.992825	0.002015	492.7019	0.0000
R-squared	0.994011	Mean dependent var		13.93057
Adjusted R-squared	0.993739	S.D. dependent var		1.095924
S.E. of regression	0.086719	Sum squared resid		0.165444
Durbin-Watson stat	1.650918	J-statistic		0.358389

Table 17 Estimation output of import equation (M)

Dependent Variable: $LN(M)$

Method: Generalized Method of Moments

Date: 09/25/08 Time: 22:36

Sample(adjusted): 1982 2005

Included observations: 24 after adjusting endpoints

Kernel: Bartlett, Bandwidth: Fixed (2), No prewhitening

Simultaneous weighting matrix & coefficient iteration

Convergence achieved after: 77 weight matrices, 78 total coef iterations

Instrument list: $Tx_{ii} Tx_{ci} Tx_v Tx_e Tx_c D97 GWP LN(X_{-1}) LN\left(\frac{RD}{RW}\right)$

$LN(Ex_{-1}) SD G LN(D) LN(RD) LN(L) LN(MI) P$

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$LN(GDP)$	1.175017	0.057533	20.42321	0.0000
$LN(X)$	0.181048	0.036164	5.006259	0.0001
C	-5.984047	0.352097	-16.99544	0.0000
R-squared	0.991780	Mean dependent var		13.95406
Adjusted R-squared	0.990998	S.D. dependent var		1.018401
S.E. of regression	0.096627	Sum squared resid		0.196073
Durbin-Watson stat	0.772591	J-statistic		0.318816

Table 18 Estimation output of interest rate equation (RL)

Dependent Variable: $LN(RL)$

Method: Generalized Method of Moments

Date: 08/29/08 Time: 04:59

Sample(adjusted): 1982 2005

Included observations: 24 after adjusting endpoints

Kernel: Bartlett, Bandwidth: Fixed (2), No prewhitening

Simultaneous weighting matrix & coefficient iteration

Convergence achieved after: 3 weight matrices, 4 total coef iterations

Instrument list: $Tx_{ii} Tx_{ci} Tx_v Tx_e Tx_c D97 GWP LN(X_{-1}) LN\left(\frac{RD}{RW}\right)$

$LN(Ex_{-1}) SD G LN(D) LN(RD) LN(L) LN(MI) P$

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.316625	0.830938	6.398345	0.0000
$LN(RD)$	0.298171	0.069538	4.287903	0.0004
$LN(L)$	0.302232	0.098585	3.065683	0.0061

LN(MI)	-0.624653	0.163127	-3.829252	0.0010
R-squared	0.952895	Mean dependent var	2.401611	
Adjusted R-squared	0.945829	S.D. dependent var	0.353952	
S.E. of regression	0.082381	Sum squared resid	0.135733	
Durbin-Watson stat	1.666783	J-statistic	0.001284	

Table 19 Estimation output of exchange rate equation (*E*)

Dependent Variable: LN(*E*)

Method: Generalized Method of Moments

Date: 09/25/08 Time: 22:36

Sample(adjusted): 1982 2005

Included observations: 24 after adjusting endpoints

Kernel: Bartlett, Bandwidth: Fixed (2), No prewhitening

Simultaneous weighting matrix & coefficient iteration

Convergence achieved after: 48 weight matrices, 49 total coef iterations

Instrument list: Tx_{ii} Tx_{ci} Tx_v Tx_e Tx_c $D97$ GWP $LN(X_{-1})$ $LN\left(\frac{RD}{RW}\right)$

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.679853	0.064071	-26.21850	0.0000
$LN\left(\frac{RD}{RW}\right)$	-0.084385	0.007454	-11.32076	0.0000
$LN\left(\frac{X}{M}\right)$	-0.417545	0.029531	-14.13909	0.0000
$D97$	-0.225844	0.011888	-18.99732	0.0000
$LN(Ex_{-1})$	0.484122	0.020007	24.19732	0.0000
R-squared	0.940299	Mean dependent var	-3.393759	
Adjusted R-squared	0.927731	S.D. dependent var	0.237303	
S.E. of regression	0.063794	Sum squared resid	0.077324	
Durbin-Watson stat	1.516335	J-statistic	0.265384	

The last three equations are identities:

$$GDP = PC + I + G + X - M + SD$$

$$RRL = \frac{(100 + RL)}{\left(\frac{P}{P_{-1}}\right)}$$

$$ST = PC + G + X - Tx_{ii} - Tx_{ci} - Tx_v - Tx_e - Tx_c$$

6.3 PANEL STRUCTURAL BREAK MODEL

The panel structural break model is used to test for structural breaks and estimate tax evasion in Southeast Asia and South Korea.

Table 20 Estimation output of structural break demand equation

Dependent Variable: LN(C)

Method: Two-Stage Least Squares

Date: 09/11/08 Time: 15:37

Sample: 1 151

Included observations: 133

Excluded observations: 18

Instrument list: LN(RL) (LNT₇₈) LN(T_{N78}) LN(DI) D1 D2 D3 D4 D5 D6 D7 T D97

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-3.679191	0.286788	-12.82894	0.0000
LN(T ₇₈)	0.610657	0.104055	5.868571	0.0000
LN(T _{N78})	0.623335	0.100341	6.212176	0.0000
LN(DI)	0.812383	0.027668	29.36153	0.0000
LN(R)	-0.154442	0.049672	-3.109228	0.0023
T	-0.008694	0.003673	-2.366604	0.0196
D1	-0.937366	0.102882	-9.111072	0.0000
D2	-0.203401	0.113403	-1.793609	0.0754
D3	-0.148646	0.073206	-2.030530	0.0445
D4	-0.277500	0.078252	-3.546238	0.0006
D5	-0.280311	0.097807	-2.865958	0.0049
D6	-0.462952	0.100740	-4.595503	0.0000
D7	-0.105780	0.076341	-1.385621	0.1684
R-squared	0.990534	Mean dependent var		-2.855441
Adjusted R-squared	0.989588	S.D. dependent var		1.148651
S.E. of regression	0.117208	Sum squared resid		1.648527
F-statistic	1046.007	Durbin-Watson stat		0.837987
Prob(F-statistic)	0.000000			

Table 21 Estimation output of structural break supply equation

Dependent Variable: LN(R)

Method: Two-Stage Least Squares

Date: 09/12/08 Time: 00:06

Sample(adjusted): 5 151

Included observations: 102

Excluded observations: 45 after adjusting endpoints

Instrument list: LN(RL) (LNT₇₈) LN(T_{N78}) LN(DI) D1 D2 D3 D4 D5 D6 D7 T D97

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2.043104	0.483685	-4.224042	0.0001
LN(D)	-0.213839	0.076980	-2.777859	0.0066
LN(RL)	1.458762	0.172324	8.465244	0.0000
D1	-2.060634	0.258831	-7.961303	0.0000
D2	0.558098	0.277251	2.012971	0.0470
D4	0.340789	0.227021	1.501138	0.1367
D5	0.144406	0.240277	0.600997	0.5493
D6	0.965677	0.309890	3.116195	0.0024
D7	0.542983	0.272586	1.991967	0.0493
D97	-0.287968	0.101014	-2.850780	0.0054
R-squared	0.869719	Mean dependent var		1.777093
Adjusted R-squared	0.856974	S.D. dependent var		0.840104
S.E. of regression	0.317717	Sum squared resid		9.286850
F-statistic	68.28604	Durbin-Watson stat		0.419133
Prob(F-statistic)	0.000000			

7 APPENDIX 2: MATHEMATICAL PROCEDURE OF TAX EFFECTIVENESS

This is an example for the calculation of the tax effectiveness of individual income tax. The other four main taxes are calculated in the same way.

The first step is to estimate the total effect of tax rate on currency; this step is same as in the Tanzi approach to estimating illegal money. The estimated record currency in column (1) is calculated from the equilibrium of the demand and supply equations at the recorded tax rates. Column (2) presents the calculated legal currency by setting the individual income tax rate at zero. Difference between the two estimated currencies as shown in (3) is converted to total tax rate effects on currency in (5) by dividing with $M2$ in (4). The total effects are presented as a percent change of currency per unit of broad money ($M2$).

The second step is to estimate the legal tax rate effects on currency through the significant transactions (ST) from the legal effect equations. The process of the calculation is similar to the first process. ST is calculated twice; at the recorded and zero individual income tax rates. The results are shown in column (6) and (7). The percentage change of ST is defined as the legal tax rate effect in column (9). The illegal tax rate effect in column (10) is indicated as the legal effect (9) subtracted from the total effect (5). The velocity of money (v) in (13) is defined as the tax base over broad money $\left(v = \frac{tb}{M2} \right)$. The illegal effect (10) multiplied by $M2$ (4) is illegal money (IM , 11).

The underground economy (UE , 14) is estimated by the multiplication of illegal money (IM , 11) and the velocity of money (v , 13).

Tax evasion (16) is estimated as the underground economy (14) multiplied by the tax rate (16). Finally, the effectiveness of tax collection (18) is estimated from the ratio of the tax revenue (17) to tax evasion (16) plus the tax revenue (17).

Table 22 Example to estimate the effectiveness of tax collection of individual income tax from the model

Millions of baht

	\hat{C}	\hat{C}_{ii}	$\hat{C} - \hat{C}_{ii}$	$M2$	$\% \left(\hat{C} - \hat{C}_{ii} \right),$	\hat{ST}	\hat{ST}_{ii}	$\hat{ST} - \hat{ST}_{ii}$	$\% \left(\hat{ST} - \hat{ST}_{ii} \right),$									
	(1)	(2)	(3)=	(4)	(5)=	(6)	(7)	(8)=	(9)=	(10)=	(11)=	(12)	(13)=	(14)=	(15)	(16)=	(17)	(18)=
			(1)-(2)		$\frac{(3)}{(4)} \times 100$			(6)-(7)	$\frac{(8)}{(6)} \times 100$	(5)-(9)	$\frac{(10)}{100} \times (4)$		$\frac{(12)}{(4)}$	(12)×(13)		$\frac{(15)}{(12)}$		$\frac{(15)}{(15)+(17)}$
1983	58,597	70,792	-12195	491,774	-2.48%	728,699	778,224	-49,525	-6.80%	4.32%	21227	713,156	1.4502	30,783	15,397	2.16%	665	0.9586
1984	63,277	77,226	-13949	588,509	-2.37%	668,271	725,665	-57,394	-8.59%	6.22%	36595	759,236	1.2901	47,211	17,919	2.36%	1114	0.9415
1985	61,718	75,982	-14264	655,980	-2.17%	803,016	868,018	-65,002	-8.09%	5.92%	38836	810,837	1.2361	48,004	20,619	2.54%	1221	0.9441
1986	72,212	88,042	-15830	745,349	-2.12%	888,280	952,577	-64,297	-7.24%	5.11%	38122	857,360	1.1503	43,851	20,059	2.34%	1026	0.9513
1987	90,997	109,762	-18765	890,187	-2.11%	1,068,146	1,136,621	-68,475	-6.41%	4.30%	38301	969,743	1.0894	41,724	20,645	2.13%	888	0.9587
1988	103,317	125,822	-22505	1,050,090	-2.14%	1,338,772	1,425,750	-86,978	-6.50%	4.35%	45718	1,133,965	1.0799	49,370	26,269	2.32%	1144	0.9583
1989	123,199	149,874	-26675	1,324,970	-2.01%	1,769,191	1,869,554	-100,363	-5.67%	3.66%	48488	1,341,706	1.0126	49,100	30,793	2.30%	1127	0.9647
1990	136,546	170,830	-34284	1,663,090	-2.06%	1,911,957	2,047,174	-135,217	-7.07%	5.01%	83333	1,508,631	0.9071	75,593	43,860	2.91%	2198	0.9523
1991	157,559	198,268	-40709	1,985,650	-2.05%	2,105,785	2,266,540	-160,755	-7.63%	5.58%	110875	1,704,523	0.8584	95,177	51,953	3.05%	2901	0.9471
1992	176,215	219,751	-43536	2,293,700	-1.90%	2,701,849	2,862,776	-160,927	-5.96%	4.06%	93081	1,881,657	0.8204	76,360	53,280	2.83%	2162	0.9610
1993	211,994	264,924	-52930	2,729,300	-1.94%	3,113,383	3,294,781	-181,398	-5.83%	3.89%	106090	2,078,256	0.7615	80,783	59,869	2.88%	2327	0.9626
1994	239,087	301,157	-62070	3,020,950	-2.05%	3,701,737	3,919,876	-218,139	-5.89%	3.84%	115951	2,292,077	0.7587	87,975	70,419	3.07%	2703	0.9630
1995	274,022	350,176	-76154	3,556,950	-2.14%	4,372,222	4,654,470	-282,248	-6.46%	4.31%	153465	2,664,038	0.7490	114,940	91,795	3.45%	3960	0.9586
1996	293,014	380,238	-87224	3,934,710	-2.22%	5,108,795	5,437,822	-329,027	-6.44%	4.22%	166187	2,893,821	0.7355	122,224	112,306	3.88%	4743	0.9595
1997	309,354	400,850	-91496	4,703,970	-1.95%	4,699,817	5,009,221	-309,404	-6.58%	4.64%	218182	3,030,574	0.6443	140,565	116,291	3.84%	5394	0.9557
1998	300,664	393,083	-92420	5,177,640	-1.78%	4,753,289	5,040,223	-286,934	-6.04%	4.25%	220130	3,111,927	0.6010	132,305	127,817	4.11%	5434	0.9592
1999	413,073	521,108	-108035	5,374,340	-2.01%	5,747,296	5,960,111	-212,815	-3.70%	1.69%	90970	3,098,578	0.5766	52,449	96,375	3.11%	1631	0.9834
2000	366,023	459,546	-93523	5,638,110	-1.66%	5,760,331	5,972,574	-212,243	-3.68%	2.03%	114216	3,198,598	0.5673	64,797	95,711	2.99%	1939	0.9801
2001	398,541	502,842	-104301	5,945,710	-1.75%	6,891,106	7,114,774	-223,668	-3.25%	1.49%	88682	3,277,556	0.5512	48,886	102,050	3.11%	1522	0.9853
2002	448,424	568,762	-120339	6,170,730	-1.95%	6,940,778	7,182,384	-241,606	-3.48%	1.53%	94462	3,397,192	0.5505	52,005	110,319	3.25%	1689	0.9849
2003	527,357	671,320	-143962	6,849,560	-2.10%	6,920,955	7,191,304	-270,349	-3.91%	1.80%	123598	3,684,707	0.5379	66,489	123,163	3.34%	2222	0.9823
2004	568,938	724,783	-155845	7,222,780	-2.16%	7,615,124	7,913,082	-297,958	-3.91%	1.76%	126761	4,061,436	0.5623	71,279	136,545	3.36%	2396	0.9828
2005	620,449	791,086	-170636	7,646,870	-2.23%	8,855,144	9,175,847	-320,703	-3.62%	1.39%	106307	4,396,444	0.5749	61,120	148,815	3.38%	2069	0.9863

8 APPENDIX 3: TANZI'S MONETARY APPROACH VERSUS THE ADAPTED MODEL

This section has the purpose to recheck 1) how is Tanzi's approach used, and 2) can the adapted model be used universally or not, due to the reason that there are significant differences between the results of Tanzi's approach and the adapted model.

In order to check Tanzi's approach, his data was taken and calculated according to the process he lays out in his approach. The produced results were not similar to what he came up with. On closer observation, there are two doubts about the adjustments made in his calculated results. The first adjustment in doubt is the amount of illegal money; this is for scaling the size of tax evasion down. It is noticed that the figure for illegal money is negative in 1930-1931. As there is a positive relationship between tax rate and currency, the positive tax rate should not product the negative illegal money. The second adjustment in doubt is the tax evasion results by using the data from Tanzi's paper, the average tax rate in the paper is a lot lower than the effective tax rate so the results produced from the effective tax rate were much higher then that the published results in the paper. The reason for the oddly low tax evasion in Tanzi's research is unacceptable, however the reason for the extremely high results using Tanzi's approach in the Thai context can be explained by the velocity of legal money. It could be confirmed that Tanzi's results are correct calculations as the process in the literature though the track of calculation shows different results.

The adapted model is applied to the updated United State context to recheck the universal property. With updated data, estimation output of Tanzi's approach (Table 23) presents Adjusted R-squared at 0.8003, while both outputs of the adapted model (total effective tax rate variable and four main effective tax rate variables) present higher Adjusted R-squared at 0.9862 (Table 24) and 0.9841 (Table 25) respectively. These present the universal appropriation for estimating tax evasion.

Table 23 Estimation output of Tanzi's monetary approach

Dependent Variable: $\text{LN}\left(\frac{C}{M2}\right)$

Method: Least Squares

Date: 07/02/08 Time: 18:28

Sample(adjusted): 1960 2007

Included observations: 48 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
c	-8.460516	3.624222	-2.334436	0.0243
LN(T)	2.130823	0.343692	6.199810	0.0000
$\text{LN}\left(\frac{WS}{NI}\right)$	-0.944180	0.830698	-1.136611	0.2620
LN(R)	-0.228089	0.025408	-8.977018	0.0000
LN(Y)	0.363130	0.080340	4.519931	0.0000
R-squared	0.817299	Mean dependent var	-2.512311	
Adjusted R-squared	0.800303	S.D. dependent var	0.193710	
S.E. of regression	0.086564	Akaike info criterion	-1.957532	
Sum squared resid	0.322213	Schwarz criterion	-1.762615	
Log likelihood	51.98077	F-statistic	48.08917	
Durbin-Watson stat	1.072836	Prob(F-statistic)	0.000000	

Table 24 Estimation output of demand and supply for currency equation in form A

Dependent Variable: $\text{LN}\left(\frac{C}{P}\right)$

Method: Generalized Method of Moments

Date: 09/19/08 Time: 21:16

Sample(adjusted): 1960 2007

Included observations: 48 after adjusting endpoints

Kernel: Bartlett, Bandwidth: Fixed (3), No prewhitening

Simultaneous weighting matrix & coefficient iteration

Convergence achieved after: 3 weight matrices, 4 total coef iterations

Instrument list: LN(RL) LN(T) $\text{LN}\left(\frac{WS}{P}\right)$ LN(Y)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LN(T)	0.850564	0.178861	4.755444	0.0000
$\text{LN}\left(\frac{WS}{P}\right)$	1.715489	0.072268	23.73795	0.0000
LN(R)	-0.204452	0.015527	-13.16742	0.0000
LN(Y)	-0.691707	0.074204	-9.321740	0.0000
R-squared	0.987097	Mean dependent var	0.945478	
Adjusted R-squared	0.986217	S.D. dependent var	0.519289	
S.E. of regression	0.060964	Sum squared resid	0.163532	
Durbin-Watson stat	1.094194	J-statistic	0.000123	

Dependent Variable: LN(R)

Method: Generalized Method of Moments

Date: 09/19/08 Time: 21:20
Sample(adjusted): 1960 2007
Included observations: 48 after adjusting endpoints
Kernel: Bartlett, Bandwidth: Fixed (3), No prewhitening
Simultaneous weighting matrix & coefficient iteration
Convergence achieved after: 9 weight matrices, 10 total coef iterations

Instrument list: $\text{LN}(RL)$ $\text{LN}(T)$ $\text{LN}\left(\frac{WS}{P}\right)$ $\text{LN}(Y)$

Variable	Coefficient	Std. Error	Prob.
c	0.872052	0.285538	0.0038
$\text{LN}\left(\frac{D}{P}\right)$	-0.462636	0.076139	0.0000
$\text{LN}(RL)$	1.226537	0.076945	0.0000
R-squared	0.888013	Mean dependent var	1.750050
Adjusted R-squared	0.883035	S.D. dependent var	0.529921
S.E. of regression	0.181233	Sum squared resid	1.478049
Durbin-Watson stat	0.453564	J-statistic	0.037064

Table 25 Estimation output of demand and supply for currency equation in form B

Dependent Variable: $\text{LN}\left(\frac{C}{P}\right)$

Method: Generalized Method of Moments

Date: 09/19/08 Time: 21:27

Sample(adjusted): 1960 2007

Included observations: 48 after adjusting endpoints

Kernel: Bartlett, Bandwidth: Fixed (3), No prewhitening

Simultaneous weighting matrix & coefficient iteration

Convergence achieved after: 1 weight matrix, 2 total coef iterations

Instrument list: $\text{LN}(T_{PI})$ $\text{LN}(T_{CI})$ $\text{LN}(T_{PC})$ $\text{LN}\left(\frac{WS}{P}\right)$ $\text{LN}(Y)$ $\text{LN}\left(\frac{GDP}{P}\right)$ $\text{LN}(RL)$

Variable	Coefficient	Std. Error	t-Statistic	Prob.
c	25.05040	8.739238	2.866428	0.0066
$\text{LN}(T_{PI})$	0.314232	0.240899	1.304412	0.1995
$\text{LN}(T_{CI})$	0.191123	0.124627	1.533557	0.1330
$\text{LN}(T_{PC})$	0.092740	0.297529	0.311701	0.7569
$\text{LN}\left(\frac{WS}{P}\right)$	1.606667	0.672924	2.387591	0.0218
$\text{LN}(R)$	-0.208578	0.031802	-6.558687	0.0000
$\text{LN}(Y)$	-3.957364	1.151575	-3.436480	0.0014
$\text{LN}(GDP/P)$	2.280327	0.940903	2.423553	0.0200
R-squared	0.986428	Mean dependent var		0.945478
Adjusted R-squared	0.984053	S.D. dependent var		0.519289
S.E. of regression	0.065576	Sum squared resid		0.172008
Durbin-Watson stat	1.108860	J-statistic		3.43E-20

Dependent Variable: $\text{LN}(R)$

Method: Generalized Method of Moments

Date: 09/19/08 Time: 21:27

Sample(adjusted): 1960 2007

Included observations: 48 after adjusting endpoints

Kernel: Bartlett, Bandwidth: Fixed (3), No prewhitening

Simultaneous weighting matrix & coefficient iteration

Convergence achieved after: 23 weight matrices, 24 total coef iterations

Instrument list: $\text{LN}(T_{PI})$ $\text{LN}(T_{CI})$ $\text{LN}(T_{PC})$ $\text{LN}\left(\frac{WS}{P}\right)$ $\text{LN}(Y)$ $\text{LN}\left(\frac{GDP}{P}\right)$ $\text{LN}(RL)$

Variable	Coefficient	Std. Error	t-Statistic	Prob.
c	0.507561	0.230427	2.202698	0.0328
$\text{LN}\left(\frac{D}{P}\right)$	-0.698363	0.067640	-10.32471	0.0000
$\text{LN}(RL)$	1.808461	0.100421	18.00871	0.0000
R-squared	0.839705	Mean dependent var		1.750050
Adjusted R-squared	0.832580	S.D. dependent var		0.529921
S.E. of regression	0.216827	Sum squared resid		2.115635
Durbin-Watson stat	0.467274	J-statistic		0.084671

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